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ANALYSIS OF WIDEBAND SCOPE CREEK REPORT DATA USING COMPUTER TECHNIQUES

THESIS

GE/EE/76D-39

Earl F. Reynolds
Capt USAF

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(14) AFIT/
GE/EE/76D-39

(6) ANALYSIS OF WIDEBAND SCOPE CREEK REPORT
DATA USING COMPUTER TECHNIQUES.

(9) Master's thesis,

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

(12) 150p.

by

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Capt USAF
Graduate Electrical Engineering

(11) December 1976

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Preface

This report is the culmination of my efforts to develop a computer program to perform analysis on data measured on communications systems by Scope Creek teams. When I was searching for a thesis topic, I was interested in finding one which blended my background as a Scope Creek engineer and my desire to learn more about communications systems. I found such a topic in a thesis proposal made by the Scope Creek analysis officer at AFCS. On the surface the problem seemed quite straightforward. However, the many different variations in Scope Creek testing soon made it most challenging.

To the many individuals who made the results possible by contributing their advice, guidance, and assistance, I am deeply appreciative. Special thanks are expressed to Captain Greg Vaughn for the guidance and encouragement he gave me during this effort.

Finally, I must express my gratitude to my wife [redacted] for her patience and understanding during the months required to complete this work.

Earl F. Reynolds

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Abstract

A computer program which performs analysis on data measured during Scope Creek evaluations has been developed. The program is capable of analyzing data measured on both line-of-sight and tropo-scatter communications systems. Both individual equipment and system measured data can be analyzed by the program. The output of the program is a series of data comparison tables and error messages which identify problems in the measured data.

The models used by Scope Creek engineers, and in the program, to predict theoretical performance of communications systems are presented. Recommendations are given to improve the accuracy of the theoretical models and usefulness of the Scope Creek data.

ANALYSIS OF WIDEBAND SCOPE CREEK REPORT DATA USING COMPUTER TECHNIQUES

I. Introduction

Statement of Problem

The purpose of this study is to develop a computer program to perform a detailed analysis of data measured on various types of communications systems. The required analysis consists of manipulating the measured data to determine system/link noise performance, transmission path characteristics, and equipment performance. The final result of the data analysis is a comparison of measured system noise performance with theoretical system noise performance.

Definition of Basic Terms. The following basic terms are defined to help clarify the material discussed in this thesis:

1. A communications link is a portion of a communications system consisting of a transmitter, a transmit antenna, the transmission media between antennas, a receive antenna, and a receiver (Ref 1:A1-7).

2. A microwave communications link is a radio link which operates at frequencies above 1000 MHz (Ref 1:A1-8).

3. A line-of-sight (LOS) communications link is a microwave radio link in which the transmission path between the transmitter and

receiver is obstacle free (Ref 1:A1-7).

4. A troposcatter communications link is a communications link in which electromagnetic energy is propagated beyond the LOS horizon using the scattering which results from irregularities or discontinuities in the physical properties of the troposphere (Ref 1: A1-13).

5. Idle channel noise (ICN) is the residual noise in a communications channel in which no communications traffic is being passed. ICN is the sum of all the noise from various sources in a communications channel (Ref 1:A1-6).

6. A wideband communications link is a communications link in which the bandwidth of the transmitted signal exceeds 20 KHz (Ref 1: A1-14).

Background Information. The Scope Creek Evaluation Program was developed by the Air Force Communications Service (AFCS) as directed by the Defense Communications Agency (DCA) to evaluate the performance and quality of military communications systems located throughout the world. The original intent of the program was to establish a data base consisting of measured parameters such as system noise, equipment characteristics, and transmission path data that could be used to improve the design of future communications systems (Ref 3:2). As the program matured, however, maintenance assistance and the training of maintenance personnel also became very important parts of the program. These developments added a

new dimension to the evaluation program that has resulted in a substantial improvement in the quality and reliability of existing communications systems.

Although maintenance assistance and training are very important parts of the evaluation program, the final product of the Scope Creek evaluations is a voluminous report containing vast amounts of data measured on the radio and multiplex equipment installed at the communications facilities. In order for this data to be useful, it must be manipulated and compared to theoretical data and specifications available from equipment manufacturer's and communications theory. This thesis is the result of an effort to reduce the time required to perform the Scope Creek report data analysis, while at the same time improve the quality of said analysis.

Scope of the Problem. The Scope Creek Evaluation Program provides a means of evaluating the performance of all types of communications systems. In particular, evaluation teams are currently equipped to test and evaluate wideband systems, narrowband-high frequency systems, and secure voice telephone systems. The data obtained from all of these evaluations requires extensive data manipulation and analysis. An attempt to investigate appropriate prediction models and computerize the data analysis for all of these types of systems, however, would require more time than is allowed for the completion of this project. Therefore, the scope of this problem investigation is limited to the investigation and computerization of

wideband system data analysis. This limitation is acceptable since a majority of the Scope Creek reports requiring analysis are for wideband systems and the data contained in these reports are more readily adapted to computer analysis than the data in reports on other types of systems.

Problem Analysis

Assumptions. The basic assumptions on which this thesis is based are as follows:

1. Mathematical models exist that predict the performance of troposcatter and line-of-sight communications systems.

2. The mathematical models or standards available can predict transmission path loss, expected power at the receiver input, link fade margin, individual equipment noise contributions, and total expected noise within a reasonable tolerance.

3. The mathematical models can be programmed on a computer.

4. There is enough data in the Scope Creek reports provided for this study to verify the validity of the models and proper functioning of the computer program developed for this study.

Objectives. The objectives of this study are as follows:

1. to check the models presently used by Scope Creek for errors and make any necessary changes,

2. to develop a computer program to perform analysis on Scope Creek data measured on both troposcatter and LOS systems,

3. to check the tests now being performed and recommend changes or additional tests if necessary, and

4. to assure the program developed is compatible with the AFCS computer.

Criteria Used to Test Problem Solution. The following criteria is used to test the validity of the problem solution:

1. The parameters predicted by the mathematical prediction models are used to evaluate system data.

2. The performance of individual equipment is determined by comparing measured equipment parameters with standards established by AFCS, DCA, and the equipment manufacturers.

II. Theoretical Calculations

Technical measurements, whether they are taken from equipment tests or entire systems tests, have no meaning if there are no "standards" for comparison. Where equipment parameters are concerned, manufacturer's specifications provide a standard. However, system parameters (such as noise over a circuit) depend on the particular configuration of the equipment within the system, type of modulation used, and mode of signal propagation. The best approach to take in this case is to predict the value of the system parameter using known facts about the system configuration and elements of communication system engineering theory. The measurements can then be compared to the predictions to evaluate system performance.

This chapter presents the theoretical equations used in the computer program developed during this study to predict the theoretical performance of both line-of-sight and troposcatter communications systems. The theoretical predictions that are presented provide the standards against which the Scope Creek report system data is compared to determine system noise performance.

Since the objective of this thesis is not to prove communications theory but rather to use it to develop a computer program, only the equations necessary to calculate theoretical performance are presented. If the reader requires further information about a particular

equation, he may refer to the references provided which give detailed proofs and derivations of the relationships discussed.

Theoretical Calculations for LOS Systems

Calculation of Receive Signal Level, RSL. The first step in predicting the noise performance of a communications system is the determination of signal strength at the distant end receiver. This is an important parameter since the thermal noise in a communications system is inversely proportional to the RSL (as will be seen in a later discussion).

RSL is affected by many factors including transmitter power output, antenna gains, operating frequency, path length, and transmission path blockage. Given the path length (d), in KM and the frequency (f), in MHz, the unfaded RSL for a link is expressed as:

$$RSL = P_t + G_T - 20 \log (f) - 20 \log (d) - L_0 - L_t \qquad (1)$$

where P_t is the rated transmitter power (db), G_T is the total (receive, transmit, and midpath reflector, if any) antenna gain specification (dB), L_0 is the obstruction loss resulting from path blockage (dB), and L_t is the total RF transmission line and miscellaneous losses in the transmit and receive circuits (Ref 2:3-9).

The obstruction loss, L_0, in Eq (1) is a result of signal blockage by obstacles in the transmission path. This parameter is determined using the path profiles (included in each Scope Creek report) and the

obstruction loss vs. path clearance curves shown in Fig. 1 on the next page (Ref 9:3-10 and 11:107-109).

The transmission line and miscellaneous RF losses, L_t, in Eq (1) includes all losses that occur in RF transmission lines and waveguide runs, circulators, filters, etc., that are present in the transmission equipment configuration. This loss factor is obtained from on-site records and is included in the path summary sheet in the Scope Creek reports. It is the total of all line and miscellaneous losses at both the transmitter and receiver site.

<u>Calculation of FM Threshold</u>. The starting point for receiver thermal noise calculations is the thermal noise, generated in the antenna resistance. For microwave systems with an assumed effective antenna noise temperature of 290° Kelvin, the total input noise resulting from antenna resistance is expressed as (Ref 11:129):

$$N_{IN} = 10 \log (KTB_{IF}) \qquad (2)$$

where T = effective antenna temperature = 290°K

K = Boltzmann's constant = 1.38×10^{-23} joule/°K

B_{IF} = IF Bandwidth, Hz

This equation yields an input noise of -174 dBm per cycle of bandwidth. In an ideal receiver this noise would be the only source of receiver "front end" noise. An actual receiver, however, will itself contribute additional noise which will raise the equivalent noise input by the dB value of the receiver noise figure (NF). Thus, the total input front end

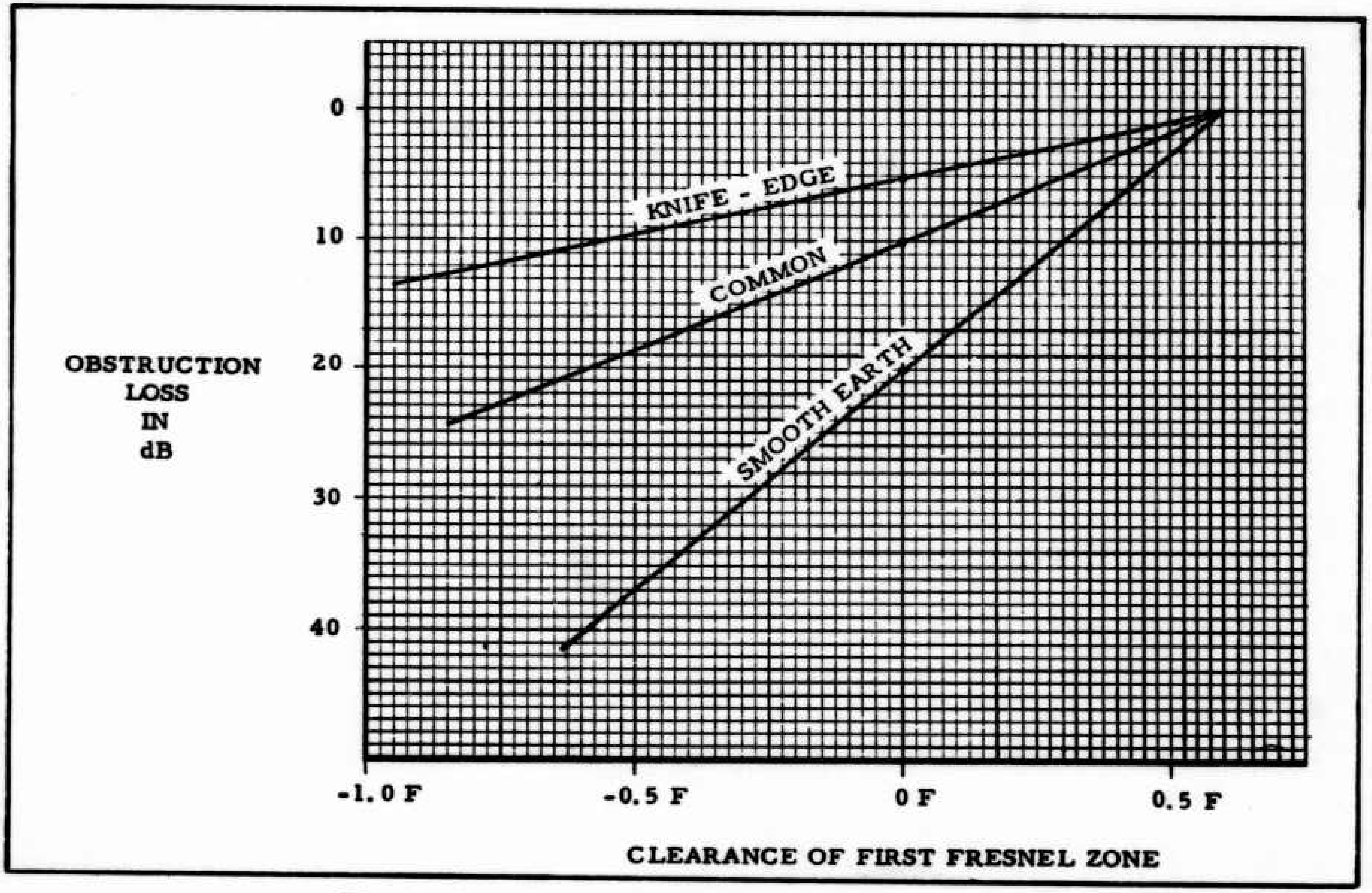

Fig. 1. Loss Due to Fresnel Zone Blockage (Ref 9)

receiver noise is calculated as:

$$N_{IN} = -174 + 10 \log B_{IF} + NF \qquad (3)$$

where B_{IF} is the receiver IF bandwidth in Hz.

Equation (3) defines one kind of threshold point and is called "detection threshold" or more simply "noise threshold." In FM LOS systems, however, this threshold does not represent a usable signal level. The true operating threshold, called FM threshold, occurs when the signal is 10 dB higher than the power of the noise. At this point, the signal peaks exceed the noise peaks 99.9% of the time and FM quieting begins. For input RSLS higher than FM threshold, the thermal noise in a channel decreases 1 dB for each 1 dB increase in input RSL.

FM threshold is expressed quantitatively as (Ref 9:68):

$$FM_{TH} = N_{IN} + 10 \text{ dB} \qquad (4)$$

or

$$FM_{TH} = -164 + 10 \log B_{IF} + NF \qquad (5)$$

where B_{IF} is in Hz and FM_{TH} is in dBm.

Calculation of Fade Margin. Fading is a general term defined as the increase in path loss between the transmitter and receiver site resulting from changes in atmospheric conditions. The quantitative treatment of fading is based largely on experience. For LOS systems

fading has been found to follow distributions generally related to the Rayleigh distribution which is normally taken as a limiting value for fading on LOS systems.

Although fading is quite random, there are ways to compensate for it. The most obvious solution is to provide extra signal strength-increased by an amount known as fade margin. Fade margin is formally defined as the dB difference between the system FM threshold (FM_{TH}) and the normal signal level (RSL). Quantitatively this is expressed as (Ref 9:71):

$$\text{Fade Margin} = \text{RSL} - FM_{TH} \tag{6}$$

where RSL is defined by Eq (1) and FM_{TH} is defined by Eq (5).

<u>Calculation of Required IF Bandwidth</u>. In an FM radio system, the IF bandwidth generally is the limiting system bandwidth. Thus, it is important that this bandwidth be wide enough to pass all channels on a multichannel system without causing sideband truncation distortion.

The receiver IF bandwidth required to pass a multichannel LOS signal without distortion is derived from the specification of the top channel modulating frequency and of the peak system deviation. Given the number of channels (N) on a multichannel system and the per-channel test tone deviation (dp), in KHz, the peak system deviation is defined as (Ref 10:880):

$$D_p = 4.47 \text{ dp} \left[\text{Antilog} \left(\frac{-15 + 10 \log N}{20} \right) \right] \tag{7}$$

if N is greater than or equal to 240 channels, and

$$D_p = 4.47 \text{ dp} \left[\text{Antilog} \left(\frac{-1 + 4 \log N}{20} \right) \right] \tag{8}$$

if N is less than 240 channels.

The required IF bandwidth for a multichannel system is then calculated as

$$B_{IF} = 2 (D_p + 2 f_m) \tag{9}$$

where D_p is the peak system deviation defined by Eq (7) or Eq (8) and f_m is the top channel modulating frequency, in KHz (Ref 11:412). The bandwidth of the installed IF amplifier/filter must be equal to or greater than the bandwidth calculated by Eq (9) in order for distortion to be minimal.

Calculation of Pre-emphasis Improvement. Most wideband FM radio systems utilize pre-emphasis networks to equalize the per channel signal-to-noise ratio (S/N) throughout the multichannel baseband. Thus, when calculating the per channel S/N, the S/N improvement resulting for the use of pre-emphasis must be included.

There are three basic types of pre-emphasis networks commonly used in radio systems: CCIR pre-emphasis, REL pre-emphasis, and time constant pre-emphasis.

The amount of pre-emphasis at a particular frequency (f) in the baseband when a CCIR pre-emphasis network is installed in the radio is calculated using the following relationship (Ref 11:262-265):

$$P = 5 - 10 \log \left[1 + \frac{6.9}{1 + \dfrac{5.25}{\left(\dfrac{1.25 f_{max}}{f} - \dfrac{f}{1.25 f_{max}}\right)^{2}}} \right] \qquad (10)$$

where f_{max} is the max baseband frequency and P is the amount of pre-emphasis at the baseband frequency (f) in dB.

The pivot frequency for a radio with CCIR pre-emphasis is calculated as:

$$f_p = 0.608 \, f_{max} \qquad (11)$$

where the pivot frequency (f_p) is defined as that single frequency for which the RMS deviation in an emphasized systems with white noise loading is equal to that of a flat system when the RMS power input to the modulator is the same in both cases.

If an REL pre-emphasis network is installed, the amount of pre-emphasis at a particular baseband frequency is calculated as (Ref 4:9):

$$P = 10 \log \left[1 + 15 \left(\frac{f}{f_{max}} \right)^2 \right] \qquad (12)$$

where P is the amount of pre-emphasis at the baseband frequency f, and f_{max} is the maximum baseband frequency.

The pivot frequency for radios with REL pre-emphasis installed is defined as:

$$f_p = f - f_{max} \left[\frac{\text{Antilog}\,(P_p/10) - 1}{15}\right]^{1/2} \tag{13}$$

where

$$P_p = 10 \log \left[\frac{1 - \frac{f_{min}}{f_{max}} + 5\left[1 - \left(\frac{f_{min}}{f_{max}}\right)^3\right]}{1 - \frac{f_{min}}{f_{max}}}\right] \tag{14}$$

The parameters f_{min} and f_{max} in Eq (14) are the minimum and maximum baseband frequencies, respectively.

Time constant pre-emphasis networks are installed in some of the older radio systems. When this type of pre-emphasis is used, the amount of pre-emphasis at a particular baseband frequency (f) is calculated as (Ref 4:10):

$$P = 10 \log (1 + 39 \cdot 5f^2 \tau^2) \tag{15}$$

where P is the amount of pre-emphasis at a particular baseband frequency (f), in dB and τ is the time constant of the pre-emphasis network, in seconds. For this type of pre-emphasis the pivot frequency is calculated as:

$$f_p = \left[\frac{f_{max}^3 - f_{min}^3}{3(f_{max} - f_{min})}\right]^{1/2} \tag{16}$$

where the parameters f_{max} and f_{min} are the maximum and minimum baseband frequencies, respectively.

Calculations of Per Channel Thermal S/N. The noise in a derived voice channel resulting from the receiver equivalent input noise is calculated, for inputs above the FM threshold, as (Ref 9:68):

$$N_{TH} = RSL - 88.5 + NF - 20 \log \frac{\Delta frms}{fch} + P_e$$
$$- 10 \log CHBW + DIF \qquad (17)$$

where N_{TH} = the noise per channel due to thermal noise in dB rn cϕ

RSL = receive signal level defined by Eq 1, in dBm

NF = receiver noise figure, in dB

Δfrms = per channel RMS deviation, in KHz

fch = baseband channel in which noise is to be found, in KHz

P_e = amount of pre-emphasis at modulating frequency minus the amount of pre-emphasis at the pivot frequency, in dB

CHBW = the bandwidth of the voice channel, in KHz

DIF = the diversity improvement factor, in dB, determined from Fig. 2 on the next page.

A more common way of expressing this noise is in the form of a signal-to-noise ratio where

$$S/N_T = RSL + 174 + NF - 20 \log \frac{\Delta frms}{fch} + P_e$$
$$- 10 \log CHBW + DIF. \qquad (18)$$

where S/N_T is in dB and all other parameters are as previously defined.

Calculation of Load Factor. Studies on operating systems by Holbrook and Dixon (Ref 8) have led to a set of equations for

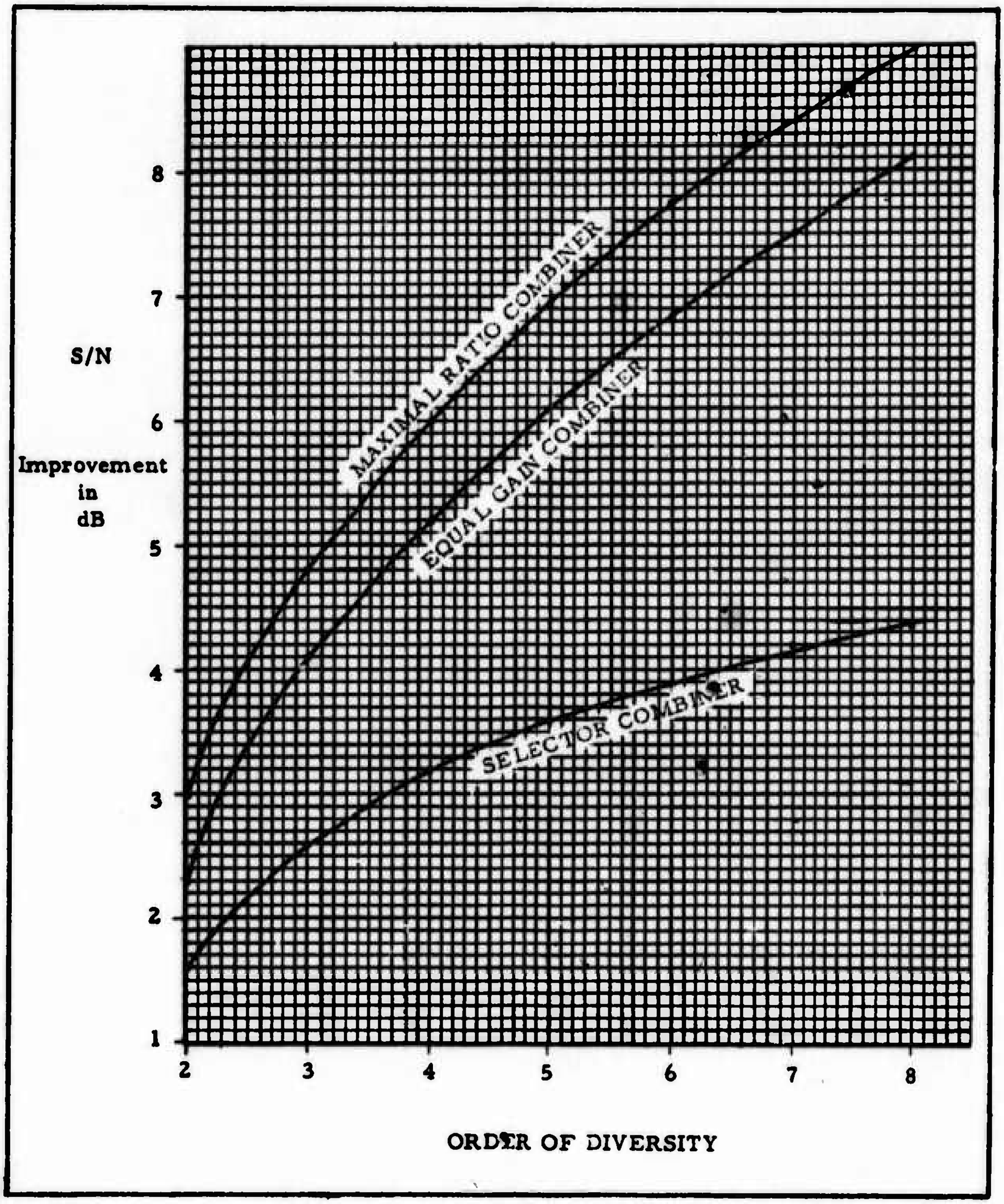

Fig. 2. Diversity Improvement Factor (Ref 2)

calculating the rms value of white noise power, simulating the equivalent busy hour load of a given number of voice channels multiplexed by single sideband suppressed carrier techniques. These equations are

$$P = -15 + 10 \log N \tag{19a}$$

if N is greater than or equal to 240 channels and

$$P = -1 + 4 \log N \tag{19b}$$

if N is less than 240 channels. The factor P in Eq (19) is the equivalent RMS white noise power applied over the same baseband spectrum as occupied by the multiplex channels.

The Defense Communications Agency has defined the equivalent power, P, as

$$P = -1 + 4 \log N \tag{20}$$

if $12 \leq N < 32$ channels and

$$P = -10 + 10 \log N \tag{21}$$

if $N > 32$ channels. These two equations are usually used to calculate P for military communications systems.

Noise Power Ratio and Signal-to-Noise Ratio. Noise power ratio (NPR) is defined as the noise in a test channel with all channels in the baseband loaded with white noise-to-noise in the test channel with all channels except the test channel fully loaded, expressed in dB. NPR

measurements show the total noise (thermal and intermodulation) that exists in a radio transmission system (Ref 11:215).

It is usually convenient to express NPR in terms of a S/N where the signal is the reference 0 dBm channel test tone; i.e. the ratio of the test tone to the noise in the channel. NPR is converted to a S/N ratio by using the following expression:

$$S/N_I(\text{dB}) = \text{NPR} + \text{BWR} - \text{P} \tag{22}$$

where $\text{BWR} = 10 \log \left[\frac{(f_{max} - f_{min})}{\text{CHBW}} \right]$

P = Equivalent power defined by Eq (20) or Eq (22), in dBmϕ

f_{max} = Maximum baseband frequency, in KHz

f_{min} = Minimum baseband frequency, in KHz

CHBW = Test channel bandwidth, on KHz.

<u>Total Per Channel System Noise</u>. The total system noise per channel is the summation of all the noise from various sources in the transmission system. Under normal operating conditions, the total noise in a channel on an LOS multichannel system is expressed as

$$N_{Total} = \text{Rcvr Thermal Noise} + \text{Intermodulation Noise} + \text{Multiplex Loaded Noise} \tag{23}$$

where all of the parameters are expressed in pwp cϕ.

Using the equations already discussed, total noise can be expressed as:

$$N_{Total} = \text{Antilog}\left[\frac{88.5 - S/N_T}{10}\right] + \text{Antilog}\left[\frac{88.5 - S/N_I}{10}\right]$$

$$+ \text{MLN (pwp c}\phi) \qquad (24)$$

where S/N_T is defined by Eq (18), S/N_I is defined by Eq (22), and MLN is the noise in a multiplex channel when all other channels are fully loaded with white noise. This relationship assumes that the RSL is at a high enough level to make the thermal noise contribution to NPR negligible. This is a valid assumption on a majority of LOS systems as a result of short path lengths and high gain antennas.

Equation (24) predicts the total noise in an LOS system in units of pwp cϕ. However, measurements are made in terms of dB mϕ or dBr N cϕ. In order to facilitate easier comparisons between predicted and measured values, N_{Total} is converted to dBrn cϕ by applying the following relationship:

$$N_{Total} \text{ (dBrn c}\phi) = 10 \log (N_{Total}). \qquad (25)$$

N_{Total} is converted to dBmϕ by using

$$N_{Total} \text{ (dBm}\phi) = 10 \log (N_{Total}) - 88.5. \qquad (26)$$

The per channel noise predicted by Eq (24) is the most important parameter associated with the determination of communication system performance. The per channel noise determines whether or not the information on a channel is intelligible when demodulated. Thus,

minimization of per channel noise is the prime objective of all Scope Creek evaluations.

Theoretical Troposcatter Calculations

The mathematical models used to predict the noise performance of troposcatter communications system are much more complicated than the models used to predict the performance of LOS systems. In fact, the subject of troposcatter system modeling is still undergoing changes and calculation methods vary from author to author. This situation results from the fact that path lengths are usually extremely long and the transmission mechanism is tropospheric refraction which is subject to continuous variations. Thus, exact calculations are extremely difficult to make. Almost all of the theoretical prediction models presently used are based on empirical observations made on numerous operational systems. Thus, the theoretical predictions that result are statistical predictions based on data measured on operational systems.

The mathematical model used by Scope Creek engineers to calculate troposcatter path loss is one proposed by the National Bureau of Standards (NBS). This model is described in detail in two volumes designated Technical Note 101 (Ref 5 and 6). Of all the models presently used, the NBS model provides path predictions over a much wider range of path and climate parameters than other models. This wider range of parameters is essential for Scope Creek calculations since

military communications systems are located throughout the world.

For the purposes of this thesis, only the basic equations needed to determine troposcatter path loss and noise performance are presented. Readers desiring more information about the equations presented in this section should refer to Ref 5, 6 and 11.

Calculation of Scatter Angle, θ. The scatter angle (θ) is the angle between the horizon rays in the great circle plane as shown in Fig. 3 on the next page. To determine this angle, the antenna take-off angles are first calculated using the following relationships and appropriate path distances as shown in Fig. 3 (Ref 5:6-5):

$$\theta_{et} = \frac{h_{Lt} - h_{ts}}{d_{Lt}} - \frac{d_{Lt}}{2a} \qquad (26a)$$

$$\theta_{er} = \frac{h_{Lr} - h_{rs}}{d_{Lr}} - \frac{d_{Lr}}{2a} \qquad (26b)$$

where θ_{et} = transmit antenna elevation angle, in radians

θ_{er} = receive antenna elevation angle, in radians

h_{Lt} = transmit radio horizon elevation above sea level, in Km

h_{Lr} = receive radio horizon elevation above sea level, in Km

d_{Lr} = distance to receive radio horizon, in Km

h_{Lt} = distance to transmit radio horizon, in Km

a = effective earth's radius, in Km.

The next step in the calculation of θ is the calculation of the angles a_0 and B_0 shown in Fig. 3. These angles are expressed as

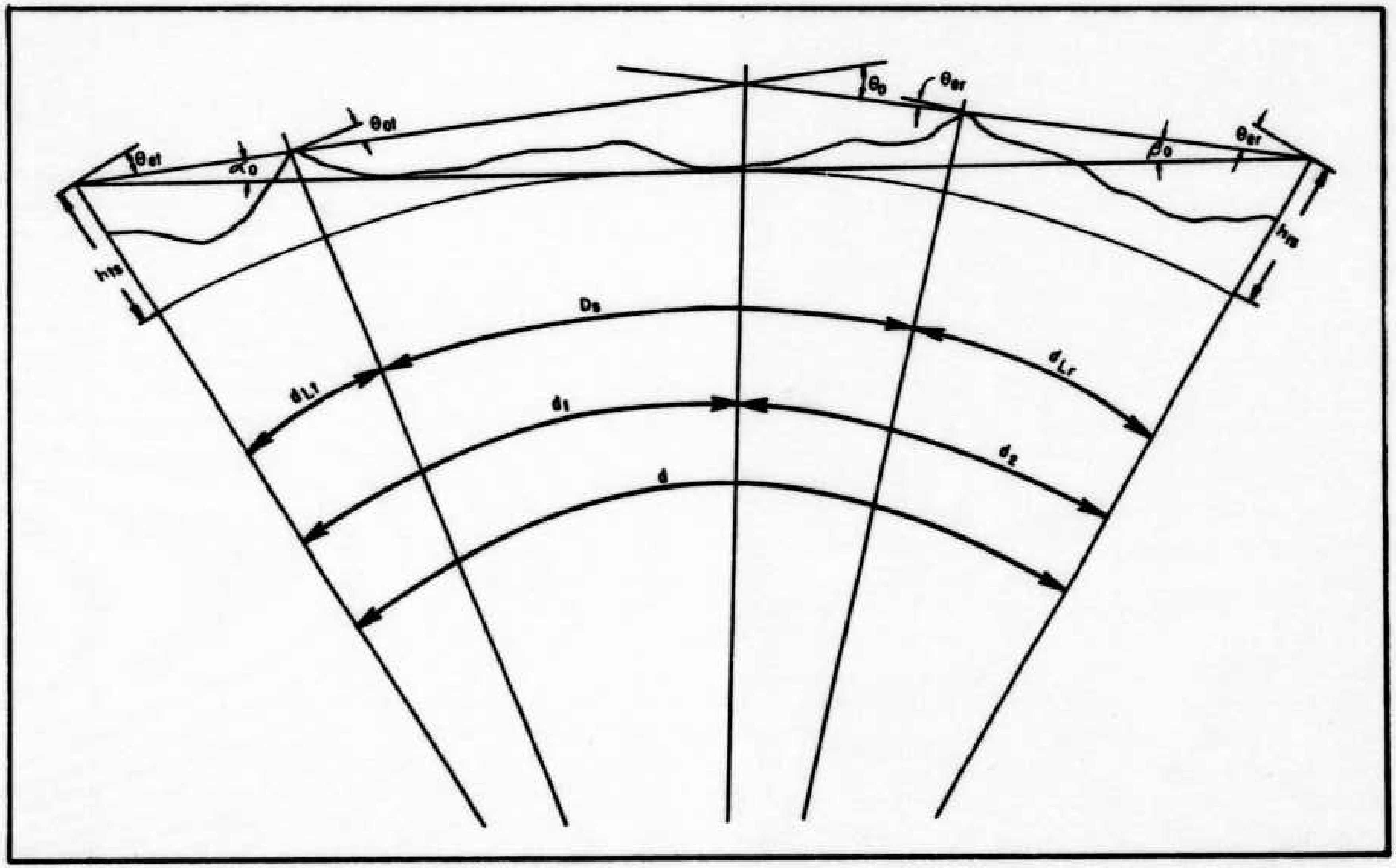

Fig. 3. Definition of Troposcatter Path Parameters (Ref 5)

(Ref 5:6-6):

$$a_0 = \frac{d}{2a} + \theta_{et} + \frac{h_{ts} - h_{rs}}{d} \tag{26c}$$

$$B_0 = \frac{d}{2a} + \theta_{er} + \frac{h_{rs} - h_{ts}}{d} \tag{26d}$$

where h_{ts} = transmit antenna elevation above sea level, in Km

h_{rs} = receive antenna elevation above sea level, in Km

d = great circle path length, in Km.

These parameters are now used to calculate the scatter angle (θ) and the path asymmetry factor (S). These two parameters are expressed as:

$$\theta = a_0 + B_0 \tag{26e}$$

$$S = a_0/B_0 \tag{26f}$$

The parameters θ and S are extremely important in the calculation of troposcatter path loss.

Basic Transmission Loss. The reference value, L_{bsr}, of long-term median basic transmission loss due to forward scatter is calculated as follows (Ref 5:9-1):

$$L_{bsr} = 30 \log (f) - 20 \log (d) + F(\theta d) - F_0 + H_0 + A_a \tag{27}$$

where f is the operating frequency in MHz, and d is the great circle path length in Km. The attenuation function $F(\theta d)$, the scattering

efficiency term F_0, the frequency-gain function H_0, and the atmospheric absorption A_a are factors that adjust the median loss for varying path lengths and frequency. These parameters are discussed in more detail in later subsections (Ref 5:9-1).

The median basic transmission loss given by Eq (27) refers to the hourly median values of the total propagation loss (excluding line and miscellaneous losses), measured over a scatter path from November to April, between the hours of 1PM and 6PM. This time period is considered the worst time for propagation and the median loss calculated with Eq (26) is approximately 3dB higher than the hourly median value (Ref 11:389).

Calculation of the Attenuation Function, $F(\theta d)$. The attenuation function $F(\theta d)$ is dependent on the most important features of the propagation path (scatter angle and path asymmetry) and upon the surface refractivity N_S. Given these parameters and the great circle path length (d), the attenuation function is calculated as follows (Ref 5: III-24):

1. Calculate the product, $\theta \cdot d$, of the scatter angle (θ) and the great circle path length (d).

2. Calculate $F(\theta d)$ for a surface refractivity, $N_S = 301$, using one of the following relationships:

a. for $0.01 \leq \theta d \leq 10$,

$$F(\theta d) = 135.82 + 0.33\theta d + 30 \log (\theta d) \tag{28a}$$

b. for $10 \leq \theta d \leq 70$,

$$F(\theta d) = 129.5 + 0.212\ \theta d + 37.5 \log (\theta d) \tag{28b}$$

c. for $\theta d \geq 70$,

$$F(\theta d) = 119.2 + 0.157 \theta d + 45 \log (\theta d). \tag{28c}$$

For values of N_S different from $N_S = 301$, $F(\theta d)$ is found by modifying the values computed for $N_S = 301$ as follows:

$$F(\theta d, N_S) = F(\theta d, N_S = 301) - \left[0.1\ (N_S - 301) e^{-\theta d/40}\right]. \tag{28d}$$

It should be noted that the accuracy of $F(\theta d)$ computed from Eq (28a)-Eq (28d) decreases as the path asymmetry factor decreases (path becomes more asymmetrical) below 0.7. However, this method of calculation is accurate for a majority of troposcatter paths since most paths are designed to have a path asymmetry factor greater than 0.7. All of the paths evaluated by Scope Creek teams have a path asymmetry factor greater than 0.7. Thus, this method of calculation is used exclusively in the computer program developed for this study.

<u>Calculation of Scattering Efficiency, F_0</u>. The scattering efficiency correction term, F_0 in Eq (27) allows for the reduction of scattering efficiency when the scattering angle occurs at great heights in the atmosphere. This situation usually occurs if the path length is greater than 500 Km. Thus, F_0 is included in the calculation of basic transmission loss only if the great circle path length exceeds 500 Km. F_0

is determined from the following relationships (Ref 5:9-5):

$$F_0 = 1.086\left(\frac{n_s}{h_0}\right)(h_0 - h_1 - h_{Lt} - h_{Lr}) \tag{29a}$$

where n_s is defined as

$$n_s = 0.5696\ h_0 \left[1 + (0.031 - 2.32\ N_S \times 10^{-3} + 5.67\ N_S^2 \times 10^{-6}) \cdot \exp(-3.8h_0^6 \times 10^{-6})\right] \tag{29b}$$

and the parameters h_0 and h_1 are defined as:

$$h_0 = \frac{Sd\theta}{(1+S)^2} \tag{29c}$$

$$h_1 = \frac{S(d-d_{Lt}-d_{Lr})\theta}{(1+S)^2} \tag{29d}$$

In these equations, d = great circle path length, in Km

d_{Lt} = distance to transmit radio horizon, in Km

d_{Lr} = distance to receive radio horizon, in Km

h_{Lt} = height of transmit radio horizon above sea level, in Km

h_{Lr} = height of receive radio horizon above sea level, in Km.

The parameters d_{Lt}, d_{Lr}, h_{Lt}, and h_{Lr} are determined from the path profiles that are included in all Scope Creek reports.

Calculation of Frequency Gain Function, H_0. As the operating frequency of a tropo system is reduced, effective antenna heights above

sea level becomes smaller, and ground-reflected energy tends to cancel direct-ray energy at the lower part of the common volume, where scattering efficiency is greatest. The frequency gain function, (H_0) in Eq (27) is an estimate of the corresponding increase in transmission loss that results from the direct-ray energy cancellation (Ref 5:9-3).

The frequency gain function is a function of effective antenna heights in terms of wavelengths, path asymmetry (S), defined by Eq (26f), and the factor n_s defined by Eq (29b). H_0 is calculated as follows:

1. Calculate the parameters r_1 and r_2 using the following relationships:

$$r_1 = (6.5808)\ (d)\ (f)\ (hte) \tag{30a}$$

$$r_2 = (6.5808)\ (d)\ (f)\ (hre) \tag{30b}$$

where hte = effective transmit antenna height, in Km

hre = effective receive antenna height, in Km

d = path length, in Km

f = operating frequency, in MHz.

2. If r_1 and r_2 are both greater than 15.0, $H_0 = 0.0$.

3. If either r_1 or r_2 is less than 15.0 and n_s is greater than or equal to 1.0,

$$H_0 = \frac{H_0(r_1, n_s) + H_0(r_2, n_s)}{2.0} + \Delta H_0 \tag{30c}$$

where ΔH_o is defined as

$$\Delta H_0 = 6\,[0.6 - \log (n_s)]\,[\log (S)]\,[\log \left(\frac{r_2}{Sr_1}\right)] \tag{30d}$$

and H_0 (r_1, n_s) and H_0 (r_2, n_s) are determined from the curves shown on Fig. 4 on the next page.

4. If either r_1 or r_2 is less than 15.0 and n_s is less than 1.0,

$$H_0 = H_0\,(n_s = 0) + n_s\,[H_0\,(n_s = 1) - H_0\,(n_s = 0)] \tag{30e}$$

where H_0 $(n_s = 1)$ and H_0 $(n_s = 0)$ are defined as

$$H_0\,(n_s = 1) = \frac{H_0\,(r_1, n_s=1) + H_0\,(r_2, n_s=1)}{2.0} + \Delta H_0\,(n_s = 1) \tag{30f}$$

$$H_0\,(n_s = 0) = 10 \log \left\{ \frac{2[1 - Hhre/hte)^2]}{r_2^2\,[h(r_1)-h(r_2)]} \right\}. \tag{30g}$$

The parameters H_0 $(r_1, n_s = 1)$ and H_0 $(r_2, n_s = 1)$ are determined from the curves shown in Fig. 4. The parameters $h(r_1)$ and $h(r_2)$ are defined as follows:

$$h(r_1) = r_1 \left\{ C_i\,(r_1) \sin (r_1) + \left[\frac{\pi}{2} - S_i\,(r_1)\right] \cos (r_1) \right\} \tag{30h}$$

$$h(r_2) = r_2 \left\{ C_i\,(r_2) \sin (r_2) + \left[\frac{\pi}{2} - S_i\,(r_2)\right] \cos (r_2) \right\} \tag{30i}$$

where $C_i(r)$ and $S_i(r)$ are approximated as

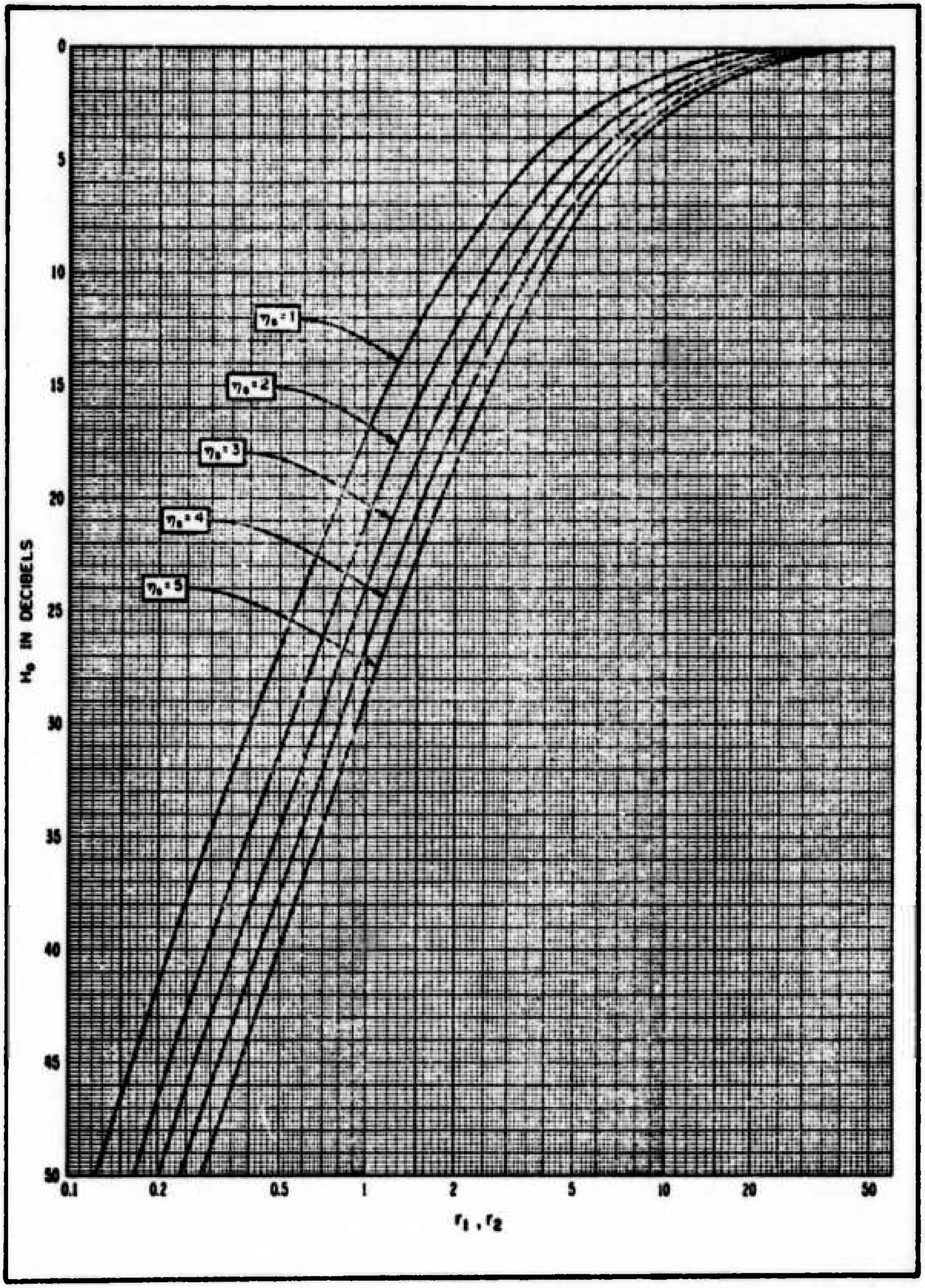

Fig. 4. The Frequency Gain Function (Ref 5)

$$C_i(r) = 0.577216 + \ln (r) + \sum_{N=1}^{\infty} (-1)^N \frac{X^{2N}}{(2N!)\,(2N)} \tag{30j}$$

$$S_i(r) = \sum_{N=1}^{\infty} (-1)^{N-1} \frac{X^{2N-1}}{(2N-1)!(2N-1)} \,. \tag{30k}$$

Determination of Atmospheric Attenuation Function, A_a. The signal attenuation resulting from oxygen and water vapor is determined from the plot of absorption vs. path length for various frequencies shown in Fig. 5 on the next page.

Long Term Power Fading. Troposcatter transmission paths are extremely susceptible to long term power fades, lasting hours or even days. The severity of these long term fades depends on path length, overall climate, and the season of the year. Empirical data collected over the years has provided a means of predicting the severity of long term fades. This data is provided in the form of plots in Ref 5. Before discussing the calculation of median transmission loss under the influence of a long term power fade, however, some basic terminology must be presented.

Time availability refers to what is commonly called reliability, i.e., the percentage of time the link/circuit exceeds a certain value or standard. For a troposcatter link, time availability usually refers to the percentage of time the received signal level exceeds a certain median value.

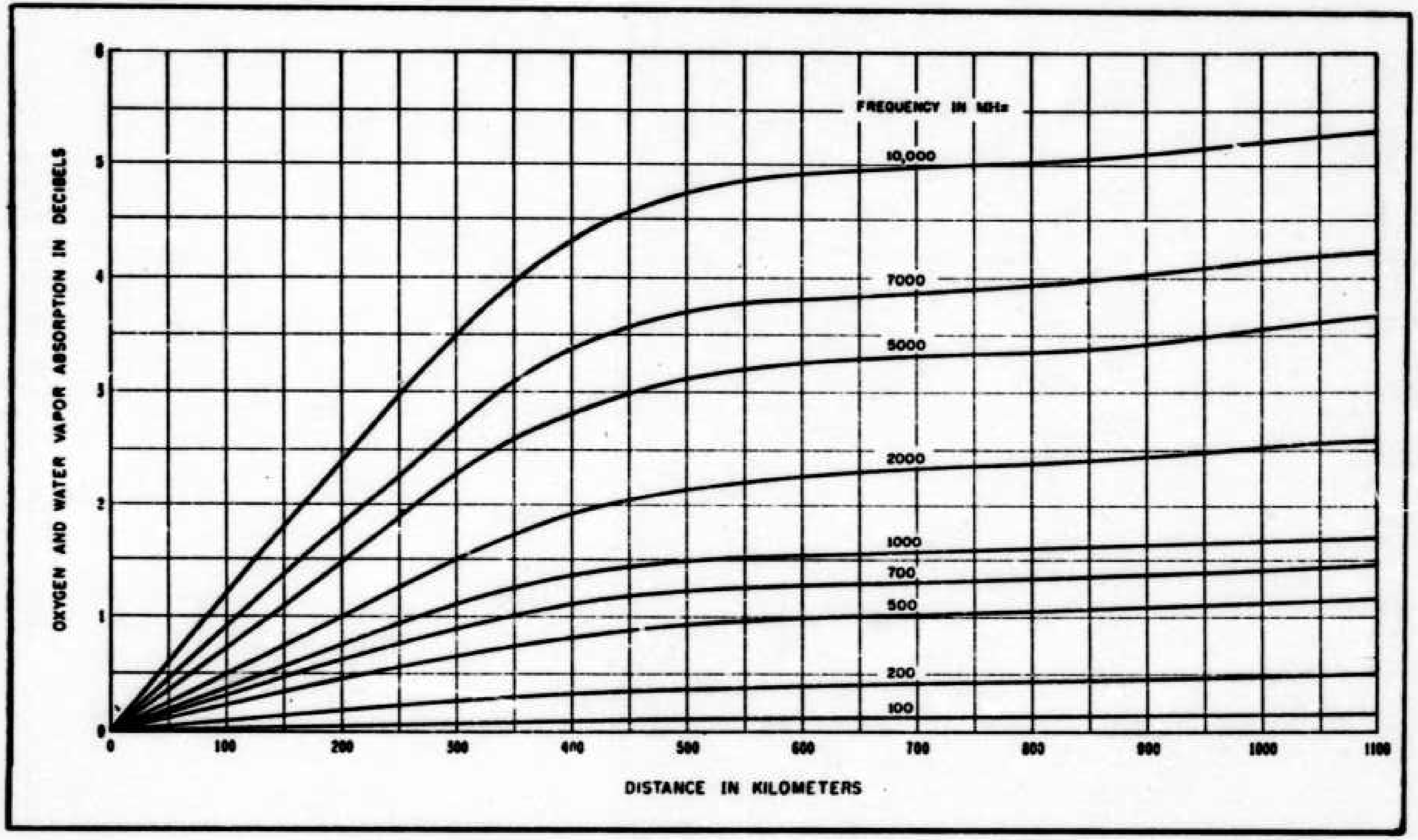

Fig. 5. Loss Due to Atmospheric Absorption (Ref 5)

The prediction formulas used in troposcatter link analysis contain many empirical terms, which can cause actual data to show appreciable deviations from predicted values. If a number of troposcatter paths, each having identical path and equipment parameters were measured for a long term received signal level, a range of overall median values would result. Service probability (F(t)) is a measure of this prediction uncertainty. It gives a confidence factor for any given prediction. For example, a median RSL of -77 dBm, F(t) = 0.95 means for 95% of all links with identical parameters will have a median RSL of -77 dBm or better.

There are standard symbols used to denote the time availability and service probability a sociated with a predicted parameter. Let p represent the percent of time the parameter equals or exceeds its value. Then, RSL (p, F(t)), represents a value of RSL exceeded p% of the time with a confidence factor F(t).

<u>Calculation of Receive Signal Level</u>. RSL for a troposcatter path is calculated as (Ref 2: 5-16):

$$RSL\,(50, 0.5) = P_t + G_T - L_{gp} - L_{bsr} - V_N\,(50, de) - L_t \quad (31a)$$

where P_t, G_T, and L_t are the same as parameters described in Eq (1). The parameter L_{gp} is aperture-to-medium coupling loss and is defined as:

$$L_{gp} = 0.07 \exp\,(0.055\, G_T) \quad (31b)$$

The parameter V_N (50, de) is a correction factor used to adjust the basic transmission loss to account for long term fading resulting from climatic variations. This parameter is determined from a plot of V_N (50, de) vs. d_e shown in Fig. 6 on the next page. The parameter de is called the effective distance and is defined as:

$$d_e = \frac{130d}{(d_{S1} - d_L)} \tag{31c}$$

if the great circle path length (d) is less than or equal to $d_{S1} + d_L$, or

$$d_e = 130 + d - d_{S1} - d_L \tag{31d}$$

if the great circle path length (d) is greater than $(d_{S1} + d_L)$. The parameters d_{S1} and d_L are defined as:

$$d_{S1} = 65 \left(\frac{0.1}{f}\right)^{1/3} \tag{31e}$$

$$d_L = 130.34 \left[\sqrt{h_{te}} + \sqrt{h_{re}}\right] \tag{31f}$$

where f = operating frequency, in MHz

h_{te} = effective transmit antenna height, in Km

h_{re} = effective receive antenna height, in Km.

<u>Calculation of FM Threshold</u>. Noise threshold and FM threshold in a troposcatter system receiver are defined nearly the same as they were for LOS systems. Equation (3) and Eq (5) are used to calculate these threshold values for tropo receivers, with one exception. A

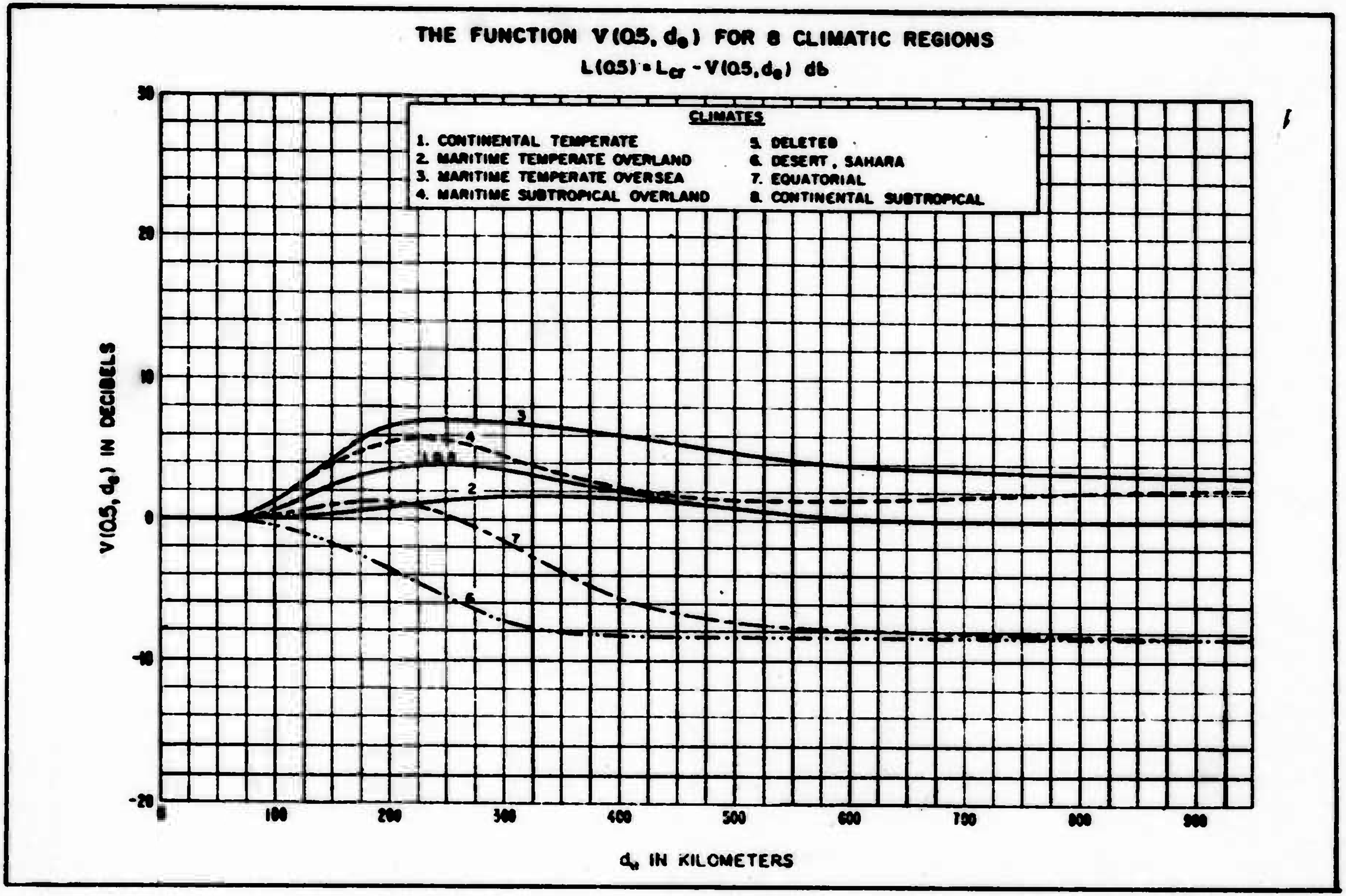

Fig. 6. Signal Variation Due to Climatic Variations (Ref 5)

provision is made in receivers on troposcatter systems to extend the FM threshold during periods of deep fades. This "new" FM threshold is called the effective FM improvement threshold and is defined as

$$EFM_{TH} = FM_{TH} - TE \tag{32}$$

where FM_{TH} is defined by Eq (5) and TE is the manufacturer's specification for threshold extension, in dB (Ref 2:5-17).

Calculation of Fade Margin. The fade margin for a troposcatter system is calculated as (Ref 2:5-17):

$$\text{Fade Margin } (50,\ 0.5) = RSL\ (50,\ 0.5) - EFM_{TH} \tag{33}$$

where RSL (50, 0.5) is defined by Eq (31a) and EFM_{TH} is defined by Eq (32).

Calculation of Required IF Bandwidth and Pre-emphasis Improvement. Required IF bandwidth and pre-emphasis improvement calculations for a troposcatter system are identical to those described in the LOS system discussions. Equation (7) through Eq (16) can be used for troposcatter calculations without any modifications being required.

Calculation of Per Channel Thermal S/N. Calculation of per channel thermal S/N in a receiver on a troposcatter system is calculated based on a service probability and time availability of 50%. The calculation procedure is a slightly modified version of Eq (18). Thus, thermal S/N ratio on a troposcatter path receiver is calculated as:

$$S/N_T\,(50, 0.5) = RSL\,(50, 0.5) + 174 + NF - 20 \log \frac{\Delta f_{rms}}{f_{ch}}$$

$$+ P_e - 10 \log CHBW + DIF \qquad (34)$$

where S/N_T (50, 0.5) = the receiver thermal S/N, in dB

RSL (50, 0.5) = median RSL calculated from Eq (31a), in dBm

NF = receiver noise figure, in dB

Δf_{rms} = per channel RMS deviation, in KHz

f_{ch} = baseband channel is which noise is found, in KHz

P_e = amount of pre-emphasis at f_{ch} minus the amount of pre-emphasis at the pivot frequency, in dB

CHBW = the bandwidth of the voice channel, in KHz

DIF = the diversity improvement factor, in dB, determined from Fig. 2.

Total Per Channel System Noise. The total predicted noise in a troposcatter system channel is essential the same as defined for LOS except for one additional term, path intermodulation which is defined as (Ref 2:5-19):

$$PI = 224.3 + 10 \log (f_{max} - f_{min}) + 40 \log (\tau_p) + 20 \log (d_p) + P \qquad (35)$$

where

f_{max} = maximum baseband frequency, in KHz

f_{min} = minimum baseband frequency, in KHz

d_p = the per channel RMS deviation, in KHz

P = equivalent white noise power defined by Eq (20) or Eq (21)

τ_p = path delay, in seconds

Path delay is defined as (Ref 2:5-19):

$$\tau_p = \left(\frac{d}{3\times10^5}\right)\left(\frac{\alpha}{2}\right)\left(\frac{\alpha}{2} + \frac{\theta_0}{2}\right) \qquad (36)$$

where d = great circle path length, in Km

α = manufacturer's specification for the antenna (smallest) half beamwidth, in rad

θ_0 = the scatter angle defined by Eq (26e).

Thus, the total predicted noise in a troposcatter channel can be expressed as:

$$N_{Total}\ (\text{pwp c}\phi) = \text{Antilog}\left[\frac{88.5 - S/N_T}{10}\right] + \text{Antilog}\left[\frac{88.5 - S/N_I}{10}\right]$$

$$+ \text{Antilog}\left(\frac{PI}{10}\right) + \text{MLN (pwp c}\phi) \qquad (37)$$

where S/N_T is defined by Eq (34), S/N_I is defined by Eq (22), PI is defined by Eq (35) and MLN is the noise in a multiplex channel when all other channels are fully loaded with white noise. As previously noted, N_{Total} calculated by Eq (37) is in units of pwp cϕ. This parameter can be converted to units of dBrNcϕ and dBmϕ by using Eq (25) and Eq (26) respectively.

Calculations Common to Both Systems

The following calculations, although not an integral part of the noise calculations, provide a further means of evaluating the receiver quieting data included in the Scope Creek reports:

1. FM improvement factor is defined as the difference between receiver noise with no input signal and the receiver noise at FM threshold. FM improvement factor can be theoretically predicted using the following relationship (Ref 4:67):

$$\text{S/N Improvement Factor} = 20 \log\left(\frac{\Delta f_{rms}}{f_{ch}}\right) + 10 \log\left(\frac{B_{IF}}{2CHBW}\right) \tag{38}$$

where the S/N improvement factor is in dB, Δf_{rms} is the per channel RMS deviation, in KHz, f_{ch} is the frequency of the channel, in KHz, B_{IF} is the IF bandwidth, in Hz, and CHBW is the bandwidth of the voice channel, in Hz.

2. The second parameter is the 20 dB quieting point defined as the RSL at which the thermal S/N in a receiver is 20 dB below the S/N ratio with no signal input. The 20 dB quieting point is predicted as:

$$\text{20 dB QP} = -165.51 + 10 \log (B_{IF}) + NF \tag{39}$$

where the 20 dB QP is in dB, B_{IF} is the IF bandwidth, in Hz, and NF is the receiver noise figure, in dB.

Summary

This chapter has presented the basic equations used to predict various theoretical parameters required in the program developed for this study. Only the major equations (along with a brief explanation) used in the program have been presented. References have been

included that will provide the reader with more information about the equations, if required.

An explanation of the program generated to implement these equations, is provided in the next chapter. A user's guide and flow charts are provided as Appendix A and Appendix B, respectively.

III. The Computer Program

The computer program developed for this thesis performs analysis on the following major equipment and system tests:

1. Receive signal level test
2. Baseband loading level test
3. Idle channel noise test
4. Link NPR test
5. IF amplifier and discriminator bandwidth test
6. RF amplifier and preselector bandwidth test
7. Transmitter frequency accuracy test
8. Receiver local oscillator frequency accuracy test
9. Receiver quieting test
10. Transmitter power output and VSWR tests
11. Multiplex noise loaded tests.

The program reads in equipment/link specifications and measured data from the tests listed above, calculates the required theoretical performance factors using the equations presented in Chapter II, and compares the measured data with the theoretical calculations and specifications. The program, also calculates the difference between measured and predicted performance, and provides the difference information, along with measured data and specifications, in tabular

as the output product of the program. If the difference between the measured performance data and theoretical data are not within required tolerances prescribed by AFCS and DCA, an error message is also printed. This message warns that tolerances are exceeded and provides information as to what other data may be affected by the discrepancy in the data.

Major Features of the Program

The computer program developed for this thesis is written in subroutine form. A calling program determines if the input data is from an LOS system or a troposcatter system and then calls an appropriate series of subroutines to perform the data analysis. There is a separate subroutine to perform the analyses required for each test previously listed. This method of development allows for easy implementation of new subroutines to perform analysis on data from new tests as they are developed. Also, if one or more of the tests listed are not performed during an evaluation, the program will still function properly and analyze the data from other tests.

Data parameters are passed between subroutines in blank common statements. This method of passing data is used so that the program can be easily converted to overlay form if the user desires to do so. This option can be implemented easily by putting overlay generator cards in place of the call subroutine statements, and replacing the subroutine header cards with the appropriate overlay identifier cards.

The language used in the program is a generalized Fortran language that is compatible with most all computers. The program should run on any general purpose computer, if the input/output statements are changed to the form of statement compatible with the new machine language. All other program statements are compatible with other machine Fortran.

Program Description

The complete program package consists of the following routines:

1. A main program decodes input data to determine the type of propagation mode and direct program control to the correct sequence of analysis routines.

2. Subroutine SPECS reads path and equipment specifications into the program. These specifications are used in the equations presented in Chapter II to calculate the parameters required to predict theoretical performance of the communications systems.

3. Subroutine THEORY calculates the theoretical parameters for LOS systems.

4. Subroutine THEO2 calculates the theoretical parameters for troposcatter systems.

5. Subroutine TI performs analysis on measured RSL, idle channel noise, and baseband loading data.

6. Subroutine T30 performs analysis on measured voltage

standing wave ratio (VSWR) and transmitter power output data.

7. Subroutine T36 performs analysis on measured noise figure data. This routine analyzes noise figure data measured on the RF preamplifier, receiver IF amplifier, and total (preamp + IF) receiver.

8. Subroutine T39 analyzes measured IF amplifier and discriminator bandwidth data.

9. Subroutine T35 performs analysis on the measured RF preamplifier and preselector bandwidth data.

10. Subroutine T34 performs analysis on measured quieting curve data. FM threshold, FM improvement factor, thermal SNR at median RSL and 20 DB quieting point are determined from this data.

11. Subroutine T27 performs analysis on measured transmitter frequency data.

12. Subroutine T37 performs analysis on measured receiver local oscillator data.

13. Subroutine T23 performs analysis on measured link NPR data.

14. Subroutine T40 performs analysis on measured multiplex NPR data.

15. Subroutine SUMM1 summarizes the measured and theoretical per channel link noise.

The output of each of these routines (except THEORY, THEO2, and SUMM1) consists of a data comparison table and error messages which identify problem areas in the measured data. Flow charts for the routines and a sample of program output are provided as Appendix

B and Appendix C, respectively.

IV. Results

Results of Model Evaluation

The mathematical models used by Scope Creek to predict theoretical parameters are well established models based on communications theory and empirical data measured on established communications links. The basic calculations used in this thesis are standard calculations recommended by DCA and are commonly accepted as "accurate" by the communications engineering community (Ref 11).

One of the objectives of this study was to check the mathematical models used by Scope Creek and verify that they are correct. This was accomplished by determining the sources of the models and comparing the sources with the models to make sure they were correct. One potential problem, concerning the calculation of total per channel link noise was identified.

Total per channel link noise is presently predicted by Eq (24) for LOS systems and Eq (36) for troposcatter systems. The potential problem with this method of prediction results from the use of NPR to calculate the S/N_I term in these equations. NPRs are a measure of total system noise, including thermal, idle, and intermodulation contributions. Since there is a thermal noise contribution, NPR is a function of RSL. If the value of the NPR used in Eq (24) and Eq (36) is

based on a high RSL, the equations will provide a reasonable prediction of total per channel noise. If, however, the value of the NPR is based on a degraded RSL, thermal noise is added into the equations twice and thus the predictions of total per channel noise will not be acceptable. This problem is particularly serious on troposcatter systems since the NPR specification used to calculate S/N_I is normally based on a low operating RSL.

Results of Program Testing

The program developed for this thesis was tested in two phases. The first phase of testing was designed to evaluate program continuity and identify programming errors. This was accomplished with data generated to force all tables and error messages to be printed. All programming errors found were corrected before the second phase of testing was started.

The second phase of testing consisted of evaluating program performance when real data was entered. The program was tested with data from three LOS evaluations and two troposcatter evaluations to determine if the program functioned properly with the type of data that will normally be evaluated by the program. The results of this test phase were compared with analysis summaries that had been previously performed manually for the Scope Creek reports. This comparison showed that the program was functioning properly and met all of the objectives established for this study.

V. Conclusions

The general conclusions drawn from this study are:

1. The models presently used by Scope Creek to predict theoretical system performance provide satisfactory predictions and required only minor modifications to make them match the equations in the sources of the models.

2. The program developed for this study performs the required analysis on data measured on both LOS and troposcatter communications systems.

3. The program is structured so that it can be easily modified to perform analysis on new tests as they become available.

4. The program can be easily adapted to overlay form.

5. The program provides a basis for future real-time data analysis when digital lines to the AFCS computer are made available to the field units.

VI. Recommendations

The following recommendations are offered to improve the accuracy of the theoretical predictions and make the computer program developed for this thesis a more valuable analysis tool:

1. The S/N_I factor in Eq (24) and Eq (36) should be replaced with an intermodulation specification (in pwp cϕ). If an intermodulation specification is not available, the total per channel noise in a troposcatter system channel should be calculated as follows:

$$N_{Total}\ (\text{pwp c}\phi) = \text{Antilog}\left(\frac{88.5 - S/N_T}{10}\right) + \text{Antilog}\left(\frac{PI}{10}\right)$$
$$+ \text{MLN}\ (\text{pwp c}\phi)$$

2. Link NPRs should be performed at median measured baseband loading and with a noise bandwidth that simulates actual installed multiplex bandwidth. This extra data will provide information concerning actual system operation and make it possible for better data correlation.

3. The baseband frequency of the voice channel in which idle channel noise (strip chart recording) was measured should be annotated in the Scope Creek reports on the strip chart recording data sheet. This piece of information will allow for better data correlation between the noise measured in individual equipment components and total per

channel noise measured on a link.

4. NPR vs baseband loading tests should be performed on a link configuration basis where the RSL is stable enough to permit such testing. This additional measurement would provide valuable information as to the source of intermodulation, echo, and thermal noise products.

5. The program developed for this study should be adapted to allow for interactive data input when a terminal becomes available for exclusive use by the report analysis office. This would eliminate the tedious job of preparing data cards and minimize data input errors.

6. The program developed for this study could possibly be modified to perform analysis on digital system test data when these tests are developed.

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Appendix A

User's Manual

This appendix describes how to input the various required data parameters to the program developed for this study.

General Rules for Data Entries

The following general rules apply to data entries:

1. All data must be entered as floating point constants.

2. Data entries must start in column one of the data card unless otherwise specified.

3. Commas must be used to separate data elements on a data card.

System Type and Station Identifier Cards

The Scope Creek reports contain data from two separate facilities. The data cards described in this section identify the type communications system installed, the names of the two facilities evaluated and the DCA link number. These three data cards are included in the data deck only once.

Type System Identifier Card. Enter one of the following codes to identify the type of transmission system that was installed on the link:

1. Enter a 1.0 if the system was an LOS system.

2. Enter a 2.0 if the system was a troposcatter system.

Station Number One Identifier Card. Enter the name of one of the stations evaluated. Information must start in column two of the data card and have the following form.

STATION NUMBER ONE - NAME OF STATION

Station Number Two Identifier Card. Enter the name of the second station evaluated. Information must start in column two on the data card. The same format should be used on this data card as was used for the Station Number One Identifier Card.

Link Identifier Data Card. Enter the six character DCA link number (such as M-1428) on this data card, starting in column one.

Path Parameters and Equipment Specifications--
Station Number One

Station Identifier Data Card. Enter the station name for which the specifications on the next group of data cards apply. This data must be entered starting in column two and it must be in the following form.

THEORETICAL DATA FROM--STATION NAME

LOS Path Parameters Data Card. If the link evaluated was a troposcatter communications link, do not include this data card in the data deck. Otherwise, enter the following parameters on this

card:

1. Enter one of the following codes to identify the type climate:

a. 1.0 for dry,

b. 2.0 for humid, or

c. 3.0 for average.

2. Enter one of the following codes to identify the type of terrain:

a. 1.0 for smooth,

b. 2.0 for average, or

c. 3.0 for rough.

3. Enter the path length (Km).

4. Enter the loss (dB) due to Fresnel Zone blockage from the K = 2/3 profile. Enter 0.0 if no blockage occurred.

5. Enter the loss (dB) due to Fresnel Zone blockage from the K = 4/3 profile. Enter a 0.0 if no blockage occurs.

6. Enter the transmit antenna gain (dB) specification.

7. Enter the receive antenna gain (dB) specification.

Line Loss and Reflector Specifications Data Card. If the link evaluated was a troposcatter communications link, do not include this data card in the data deck. Otherwise, enter the following parameters on this card:

1. Enter the total transmission line losses (dB) at the transmitter site.

2. Enter the total RF transmission line losses (dB) at the receiver site.

3. Enter total miscellaneous losses (dB) resulting from circulators, isolators, etc., at both the transmitter and receiver sites.

4. Enter a 1.0 if a periscope antenna is used in the transmission configuration. Enter a 2.0 if a periscope antenna is not used.

5. Enter a 1.0 if a midpath reflector is used in the transmission configuration. Enter a 2.0 if a midpath reflector is not used.

Periscope and Midpath Reflector Gain Specifications Data Card. If the link evaluated was a troposcatter communications link, do not include this data card in the data deck. Otherwise, enter the following parameters on this card:

1. Enter transmit side reflector gain (dB). Enter 0.0 if the antenna is not of the periscope type. If a loss results from this reflector, this entry must be a negative number.

2. Enter receive side reflector gain (dB). Enter 0.0 if the antenna is not of the periscope type. If a loss results from this reflector, this entry must be a negative number.

3. Enter the midpath reflector gain (dB). Enter a 0.0 if a midpath reflector is not used. If a loss results from this reflector, this entry must be a negative number.

Troposcatter Path Parameters--Card 1. If the link evaluated was an LOS communications link, do not include this data card in the data deck. Otherwise, enter the following parameters on this card:

1. Enter one of the following codes to identify the type climate:

   a. 1.0 for continental temperate,

   b. 2.0 for maritime temperate overland,

   c. 3.0 for maritime temperate oversea,

   d. 4.0 for maritime subtropical overland,

   e. 5.0 for maritime subtropical oversea,

   f. 6.0 for desert, Sahara,

   g. 7.0 for equatorial, or

   h. 8.0 for continental subtropical.

2. Enter the transmit terminal elevation (Km), above sea level (from path profile or AFCS Form 706).

3. Enter receive terminal elevation (Km), above sea level (from path profile or AFCS Form 706).

4. Enter the transmit antenna elevation (Km), above sea level (from path profile or AFCS Form 706).

5. Enter the receive antenna elevation (Km), above sea level (from path profile or AFCS Form 706).

6. Enter the transmit radio horizon elevation (Km), above sea level (from path profile or AFCS Form 706).

7. Enter the receive radio horizon elevation (Km), above sea level (from path profile or AFCS Form 706).

Troposcatter Path Parameters--Card 2. If the link evaluated was an LOS communications link, do not include this data card in the data deck. Otherwise, enter the following parameters on this card:

1. Enter the distance (Km) from the transmitter facility to the transmit radio horizon (from path profile or AFCS Form 706).

2. Enter the distance (Km) from the receive facility to the receive radio horizon (from path profile or AFCS Form 706).

3. Enter the great circle path length (Km).

4. Enter mean refractivity (from Fig. 4.1, page 4-6, AFSCP 100-61, Vol II).

5. Enter the mean elevation (Km) between the transmit facility and the transmit radio horizon (from path profile).

6. Enter the mean deviation (Km) between the receive facility and the receive radio horizon (from path profile).

7. Enter the manufacturer's specification for receiver threshold extension (dB).

8. Enter the half beamwidth angle for the smallest antenna installed (radians).

Transmission Line Loss Data Card. If the link evaluated was an LOS communications link, do not include this data card in the data deck. Otherwise, enter the following parameters on this card:

1. Enter the total transmission line losses (dB) at the transmitter site.

2. Enter the total transmission line losses (dB) at the receiver site.

3. Enter the total miscellaneous losses (dB) at both sites.

4. Enter the transmit antenna gain specification (dB).

5. Enter the receive antenna gain specification (dB).

Equipment Operational Frequency Data Card. This card is included for both troposcatter and LOS communication systems. Enter the following parameters on this data card:

1. Enter the number of transmitters used on the link.

2. Enter the number of receivers used on the link.

3. Enter the operational frequency (GHz) of transmitter number one.

4. Enter the operational frequency (GHz) of transmitter number two.

5. Enter the operational frequency (GHz) of receiver number one.

6. Enter the operational frequency (GHz) of receiver number two.

7. Enter the operational frequency (GHz) of receiver number three. Enter 0.0 if only two receivers were installed.

8. Enter the operational frequency (GHz) of receiver number four. Enter 0.0 if only two receivers were installed.

Diversity Data Card. This card will be included for both troposcatter and LOS communications systems. Enter the following data parameters on this data card:

1. Enter the order of diversity used on the link. Enter 0.0 if no diversity is used.

2. Enter one of the following codes to identify the type of diversity used on the link:

a. 1.0 for space,

b. 2.0 for frequency,

c. 3.0 for polarization,

d. 4.0 for a combination of the above, or

e. 5.0 for no diversity.

3. Enter the frequency separation (GHz) used on frequency diversity systems. Enter 0.0 if frequency diversity is not used.

4. Enter the antenna separation (meters) used on space diversity systems. Enter 0.0 if space diversity is not used.

5. Enter one of the following codes to identify the type combiner used at the receiver site.

a. 1.0 for a switching combiner,

b. 2.0 for a maximal ratio combiner,

c. 3.0 for equal gain or linear adder combiner, or

d. 4.0 if no combiner is used.

Equipment Specifications--Card 1. This data card is included for both troposcatter and LOS communication systems. Enter the

following data on this data card:

1. Enter the distant station rated transmitter power (dBm).

2. Enter the receiver noise figure specification (dB).

3. Enter the specified receiver IF bandwidth (MHz).

4. Enter the specified radio channel capacity.

5. Enter the specified transmitter per channel RMS deviation (KHz).

6. Enter the equipment NPR specification (dB).

7. Enter the local station rated transmitter power (dBm).

<u>Equipment Specifications--Card 2</u>. This card will be included for both LOS and troposcatter communications systems. Enter the following data on this data card:

1. Enter the specification for receiver fully quieted thermal noise (pwp c ϕ).

2. Enter the lowest baseband modulating frequency (KHz).

3. Enter the highest baseband modulating frequency (KHz).

4. Enter one of the following codes to identify the type of pre-emphasis network that was installed in the transmitter:

   a. 1.0 for CCIR,

   b. 2.0 for REL,

   c. 3.0 for time constant, or

   d. 4.0 if no pre-emphasis was installed.

5. Enter the specification for loaded multiplex noise (dB rn c ϕ).

6. Enter the specification for multiplex noise under no load

conditions (dBrn c ϕ).

7. Enter the time constant for the pre-emphasis network (seconds). Enter 0.0 if CCIR or REL network was used.

8. Enter the pivot frequency (KHz) for the pre-emphasis network.

Measured Data Inputs--Station Number One

The data card descriptions in this section apply to both LOS and troposcatter communication systems.

Station Identifier Card. Enter the name of the station at which the data in this section was measured. This information must start in column two and be entered in the following form:

*** THIS DATA WAS MEASURED AT--STATION NAME ***

Measured RSL Data--Card 1. Enter the following measured RSL data on this card:

1. Enter the RSL (dBm) exceeded 10% of the time that was measured on receiver #1. If the RSL was stable and no probability plot was made or if RSL was not measured on receiver #1, enter 0.0.

2. Enter the RSL (dBm) exceeded 50% of the time that was measured on receiver #1. If the RSL was stable and no probability plot was made, enter the median RSL measured on this receiver. If no RSL was measured on receiver #1, enter 0.0.

3. Enter the RSL (dBm) exceeded 90.0% of the time that was

measured on receiver #1. If the RSL was stable and no probability plot was made or if RSL was not measured on receiver #1, enter 0.0.

4. Enter the RSL (dBm) exceeded 10% of the time that was measured on receiver #2. If the RSL was stable and no probability plot was made or if RSL was not measured on receiver #2, enter 0.0.

5. Enter the RSL (dBm) exceeded 50% of the time that was measured on receiver #2. If the RSL was stable and no probability plot was made, enter the median RSL measured on this receiver. If no RSL was measured on receiver #2, enter 0.0.

6. Enter the RSL (dBm) exceeded 90.0% of the time that was measured on receiver #2. If the RSL was stable and no probability plot was made or if RSL was not measured on receiver #2, enter 0.0.

Measured RSL Data--Card 2. Enter the following RSL data measured on receiver #3 and receiver #4 on this data card:

1. Enter the RSL (dBm) exceeded 10% of the time that was measured on receiver #3. If the RSL was stable and no probability plot was made or if RSL was not measured on receiver #3, enter 0.0.

2. Enter the RSL (dBm) exceeded 50% of the time that was measured on receiver #3. If the RSL was stable and no probability plot was made, enter the median RSL measured on this receiver. If no RSL was measured on receiver #3, enter 0.0.

3. Enter the RSL (dBm) exceeded 90.0% of the time that was measured on receiver #3. If the RSL was stable and no probability plot was made, or if RSL was not measured on receiver #3, enter 0.0.

4. Enter the RSL (dBm) exceeded 10% of the time that was measured on receiver #4. If the RSL was stable and no probability plot was made, or if RSL was not measured on receiver #4, enter 0.0.

5. Enter the RSL (dBm) exceeded 50% of the time that was measured on receiver #4. If the RSL was stable and no probability plot was made, enter the median RSL measured on this receiver. If no RSL was measured on receiver #4, enter 0.0.

6. Enter the RSL (dBm) exceeded 90.0% of the time that was measured on receiver #4. If the RSL was stable and no probability plot was made or if RSL was not measured on receiver #4, enter 0.0.

Measured Idle Channel Noise Data Card. Enter the following measured idle channel noise data on this card:

1. Enter the LPAP idle channel noise specification (dBm ϕ) for this link.

2. Enter the idle channel noise (dBmϕ) measurement exceeded 10% of the time. If the ICN recordings were fairly constant and no probability plot was made, or if no ICN was measured at this station enter 0.0.

3. Enter the idle channel noise (dBm ϕ) exceeded 50% of the time. If no probability plot was made, enter the median value of ICN measured at this station. If no ICN was measured enter 0.0.

4. Enter the idle channel noise (dBm ϕ) measurement exceeded 99.9% of the time. If the ICN recordings were fairly constant and no

probability plot was made, or if no ICN was measured at this station enter 0.0.

Measured Baseband Loading Data Card. Enter the following measured baseband loading data on this data card:

1. Enter one of the following codes to identify if this parameter was measured or not:

   a. 1.0 if no baseband loading data was measured, or

   b. 2.0 if baseband loading data was measured.

2. Enter the baseband loading level exceeded 10% of the time. If the baseband loading level was constant and no probability plot was made, or if no loading data was measured at this station, enter 0.0.

3. Enter the baseband loading level exceeded 50% of the time. If the baseband level was stable and no probability plot was made, enter the median baseband loading measured at this station. If baseband loading level was not measured, enter 0.0.

4. Enter the baseband loading level exceeded 90.0% of the time. If the baseband loading was constant and no probability plot was made, or if no loading data was measured at this station, enter 0.0.

5. Enter the actual number of channels used on the link, i.e., the installed multiplex capacity.

Measured Power and VSWR Data Card. Enter the following measured parameters on this card:

1. Enter the equipment VSWR specification. Enter 0.0 if this data is not available. Example of entry: If VSWR specification is

1.04:1 enter 1.04.

2. Enter VSWR measured on transmitter #1. If VSWR was not measured on transmitter #1 enter 0.0.

3. Enter VSWR measured on transmitter #2. If VSWR was not measured on transmitter #2 enter 0.0.

4. Enter the power output (dBm) measured on transmitter #1. If power output was not measured on this transmitter, enter 0.0.

5. Enter the power output (dBm) measured on transmitter #2. If power output was not measured on this transmitter, enter 0.0.

Noise Figure Test Configuration Data Card. Enter the following information that describes how the noise figure test was performed:

1. Enter 0.0 if no noise figure data was measured. Enter a 1.0 if noise figure data was measured.

2. Enter a 0.0 if the receivers had no RF preamp, or if noise figure was not measured on the RF preamp. Enter a 1.0 if noise figure was measured on the RF preamp.

3. Enter 0.0 if no receiver noise figure (rest of receiver excluding preamp) was measured. Enter a 1.0 if receiver noise figure data was measured. (Note: if the receiver does not have an RF preamp, this measurement is the measurement made on the IF amplifier).

4. Enter 0.0 if no total noise figure (RF preamp + IF amp) was measured. Enter a 1.0 if total noise figure was measured.

Measured Preamp Noise Figure Data Card. This data card must not be included in the data deck if no preamp data was measured, or if the receivers had no RF preamplifiers. Otherwise, enter the following data on this data card:

1. Enter the preamp noise figure specification (dB).

2. Enter the preamp noise figure measured on receiver #1. Enter 0.0 if no data was measured on this receiver.

3. Enter the preamp noise figure measured on receiver #2. Enter 0.0 if no data was measured on this receiver.

4. Enter the preamp noise figure measured on receiver #3. Enter 0.0 if only two receivers were installed at this facility, or if data was not measured on this receiver.

5. Enter the preamp noise figure measured on receiver #4. Enter 0.0 if only two receivers were installed at this facility, or if data was not measured on this receiver.

Receiver Noise Figure Data Card. This data card must not be included in the data deck if receivers had no RF preamp or if only one (total noise figure) noise figure was measured on each receiver. Otherwise, enter the following data on this data card:

1. Enter the noise figure specification for the receiver, excluding the RF preamp (dB).

2. Enter the measured receiver noise figure (dB) measured on receiver #1. Enter 0.0 if this data was not measured on this receiver.

3. Enter the receiver noise figure (dB) measured on receiver

#2. Enter 0.0 if this data was not measured on this receiver.

4. Enter the receiver noise figure (dB) measured on receiver #3. Enter 0.0 if only two receivers were installed, or if no data was measured on this receiver.

5. Enter the receiver noise figure (dB) measured on receiver #4. Enter 0.0 if only two receivers were installed, or if no data was measured on this receiver.

Total Noise Figure Data Card. If total noise figure (preamp + IF) was not measured on any receiver, this data card must not be included in the data deck. Otherwise, enter the following data on this data card:

1. Enter the total noise figure (dB) measured on receiver #1. Enter 0.0 if no data was measured on this receiver.

2. Enter the total noise figure (dB) measured on receiver #2. Enter 0.0 if no data was measured on this receiver.

3. Enter the total noise figure (dB) measured on receiver #3. Enter 0.0 if only two receivers were installed at this facility, or if no data was measured on this receiver.

4. Enter the total noise figure (dB) measured on receiver #4. Enter 0.0 if only two receivers were installed at this facility, or if no data was measured on this receiver.

Measured IF Amplifier Data Card. Measured IF amplifier bandwidth is to be entered on this data card. If separate measurements were made on the IF amplifier and the IF filter, enter only the

data for the IF filter. If measurements were made on the total combination of the IF filter and the IF amplifier, enter this data only. The following data is required on this data card:

1. Enter the specified IF amplifier center frequency (MHz).

2. Enter the frequency (MHz) at which the lower 3dB point occurred on receiver #1. Enter 0.0 if no IF bandwidth data was measured on receiver #1.

3. Enter the frequency (MHz) at which the upper 3dB point occurred on receiver #1. Enter 0.0 if no IF bandwidth data was measured on receiver #1.

4. Enter the frequency (MHz) at which the lower 3dB point occurred on receiver #2. Enter 0.0 if no IF bandwidth data was measured on receiver #2.

5. Enter the frequency (MHz) at which the upper 3dB point occurred on receiver #2. Enter 0.0 if no IF bandwidth data was measured on receiver #2.

6. Enter the frequency (MHz) at which the lower 3dB point occurred on receiver #3. Enter 0.0 if no IF bandwidth data was measured on receiver #3, or if only two receivers were installed at the facility.

7. Enter the frequency (MHz) at which the upper 3dB point occurred on receiver #3. Enter 0.0 if no IF bandwidth data was measured on receiver #3, or if only two receivers were installed at the receiver facility.

8. Enter the frequency (MHz) at which the lower 3dB point occurred on receiver #4. Enter 0.0 if no IF bandwidth data was measured on receiver #4, or if only two receivers were installed at the receiver facility.

9. Enter the frequency (MHz) at which the upper 3Db point occurred on receiver #4. Enter 0.0 if no IF bandwidth data was measured on receiver #4, or if only two receivers were installed at the receiver facility.

Measured Discriminator Bandwidth Data Cards. The following data must be entered on this card:

1. Enter the frequency (MHz) measured on receiver #1 where the bottom portion of the discriminator curve becomes non-linear. Enter 0.0 if no data was measured on this receiver.

2. Enter the frequency (MHz) measured on receiver #1 where the upper portion of the discriminator curve becomes non-linear. Enter 0.0 if no data was measured on this receiver.

3. Enter the frequency (MHz) measured on receiver #2 where the lower portion of the discriminator curve becomes non-linear. Enter 0.0 if no data was measured on this receiver.

4. Enter the frequency (MHz) measured on receiver #2 where the upper portion of the discriminator curve becomes non-linear. Enter 0.0 if no data was measured on this receiver.

5. Enter the frequency (MHz) measured on receiver #3 where the lower portion of the discriminator curve becomes non-linear.

Enter 0.0 if no data was measured on this receiver, or if only two receivers were installed at the receiver facility.

6. Enter the frequency (MHz) measured on receiver #3 where the upper portion of the discriminator curve becomes non-linear. Enter 0.0 if no data was measured on this receiver, or if only two receivers were installed at the receiver facility.

7. Enter the frequency (MHz) measured on receiver #4 where the lower portion of the discriminator curve becomes non-linear. Enter 0.0 if no data was measured on this receiver, or if only two receivers were installed at the receiver facility.

8. Enter the frequency (MHz) measured on receiver #4 where the upper portion of the discriminator curve becomes non-linear. Enter 0.0 if no data was measured on this receiver, or if only two receivers were installed at the receiver facility.

Measured RF Preamp Bandwidth Data Card. Enter the following measured RF preamp bandwidth data on this data card:

1. Enter the RF preamp bandwidth specification (MHz). Enter 0.0 if no RF preamp was installed or if no data was measured.

2. Enter the RF preamp bandwidth (MHz) measured on receiver #1. Enter 0.0 if measurements were not performed on receiver #1.

3. Enter the RF preamp bandwidth (MHz) measured on receiver #2. Enter 0.0 if measurements were not performed on receiver #2.

4. Enter the RF preamp bandwidth (MHz) measured on receiver #3. Enter 0.0 if measurements were not performed on receiver #3,

5. Enter the RF preamp bandwidth (MHz) measured on receiver #4. Enter 0.0 if measurements were not performed on receiver #3, or if only two receivers were installed at the facility.

Measured Preselector Bandwidth Data Card. Enter the following measured preselector bandwidth data on this data card:

1. Enter the preselector bandwidth (MHz) specification.

2. Enter the preselector bandwidth (MHz) measured on receiver #1. Enter 0.0 if no preselector was installed, or if this measurement was not performed on receiver #1.

3. Enter the preselector bandwidth (MHz) measured on receiver #2. Enter 0.0 if no preselector was installed, or if this measurement was not performed on receiver #2.

4. Enter the preselector bandwidth (MHz) measured on receiver #3. Enter 0.0 if no preselector was installed, if this measurement was not performed on receiver #3, or if only two receivers were installed at the facility.

5. Enter the preselector bandwidth (MHz) measured on receiver #4. Enter 0.0 if no preselector was installed, if this measurement was not performed on receiver #3, or if only two receivers were installed at the facility.

Measured Tandem Bandwidth Data Card. Enter the following measured tandem (preselector + preamp) bandwidth on this data card:

1. Enter the tandem preselector/preamp bandwidth (MHz) measured on receiver #1. Enter 0.0 if this measurement was not

performed on receiver #1.

2. Enter the tandem preselector/preamp bandwidth (MHz) measured on receiver #2. Enter 0.0 if this measurement was not performed on receiver #2.

3. Enter the tandem preselector/preamp bandwidth (MHz) measured on receiver #3. Enter 0.0 if this measurement was not performed on receiver #3 or if only two receivers were installed at the facility.

4. Enter the tandem preselector/preamp bandwidth (MHz) measured on receiver #4. Enter 0.0 if this measurement was not performed on receiver #4 or if only two receivers were installed at the facility.

Measured Quieting Curve Data-Slot Information. Enter the following data on this data card:

1. Enter the number of input levels at which SNR measurements were made. The program is capable of handling up to 25 measurement points. Measurements exceeding 25 points should be excluded. If none of the receivers were tested, enter 0.0.

2. Enter the center frequency (KHz) of the low frequency slot in which measurements were made. If none of the receivers were tested, enter 0.0.

3. Enter the center frequency (KHz) of the mid frequency slot in which measurements were made. If none of the receivers were tested, enter 0.0.

4. Enter the center frequency (KHz) of the high frequency slot in which measurements were made. If none of the receivers were tested, enter 0.0.

Measured Quieting Curve Data-Input Level Data Cards. Three data cards are required to enter the receiver input levels at which receiver thermal SNR was measured. The following rules apply to the entry of this data:

1. If quieting curve data was not measured on any of the receivers, these three data cards must not be included in the data deck.

2. All data entries must be negative numbers (except 0.0 entries).

3. Ten data values must be entered on each of the first two data cards; five data values must be entered on the third data card.

4. The receiver input levels must be entered in ascending order as listed on the data sheets, starting with the lowest receiver input level at which measurements were made.

5. If SNR was measured at more than 25 receiver input levels, points must be liminated to make 25.

6. If SNR was measured at less than 25 receiver input levels, enough 0.0 elements must be entered to make a total of 25 data entries. For example, if SNR was measured at 20 receiver input levels, the three data cards required would look like the following:

1st Data Card: {-110.0, -105,0, -100.0, -95.0, -88.0, -86.0, -84.0, -82.0, -80.0

2nd Data Card: {-75.0, -70.0, -65.0, -60.0, -55.0, -50.0, -45.0, -40.0, -35.0, -30.0

3rd Data Card: {0.0, 0.0, 0.0, 0.0, 0.0

Receiver Quieting Curve Data-SNR Input Data Cards. Nine data cards are required for each receiver to enter the SNR measured at each of the receiver input levels. Thus, 36 cards are required if four receivers are installed or 18 cards are required if two receivers are installed. The following rules apply to the entry of this data:

1. If quieting curve data was not measured on any of the receivers, these data cards (36 or 18) must not be included in the data deck.

2. Data cards must be included only for the number of receivers (nine cards per receiver) installed on the link. Thus, if two receivers were installed, only 18 data cards are required.

3. All data entries must be negative numbers (except 0.0 entries).

4. Three data cards are required for each of the three noise slots tested (making a total of nine data cards for each receiver). Ten SNR measurements must be entered on each of the first two data cards for each slot; five SNR measurements must be entered on the third data card.

5. The SNR measurements for each slot must be entered to correspond directly to the receive signal level at which it was measured.

6. If SNR was measured at more than 25 receiver input levels in each slot, points must be eliminated to make 25 points. The points eliminated must be the ones measured at the receive signal levels that were eliminated.

7. If SNR was measured at less than 25 points in each slot, 0.0 elements must be entered to make a total of 25 data entries.

For example, consider a link which has two receivers. Twenty SNR measurements were made in the 70 KHz slot, the 534KHz, and the 1248 KHz at the receiver input levels given in the example in the previous section. The cards needed to input the SNR measurements would appear as follows:

1st Data Card:	-4.5, -4.5, -4.5, -5.0, -6.0, -10.0, -13.0, -17.5, -29.0, -44.0 (data for 70 KHz slot, RCVR #1)
2nd Data Card:	-52.0, -57.0, -62.0, -67.0, -72.0, -76.5, -79.5, -81.5, -82.5, -83.0 (data for 70 KHz slot, RCVR #1)
3rd Data Card:	0.0, 0.0, 0.0, 0.0, 0.0 (data for 70 KHz slot, RCVR #1)
4th Data Card:	-6.5, -6.5, -6.5, -6.5, -7.5, -11.0, -14.0, -18.0, -27.5, -35.0 (data for 534 KHz slot, RCVR #1)
5th Data Card:	-38.5, -43.5, -48.5, -53.5, -58.5, -63.0, -66.0, -69.0, -69.0, -69.5 (data for 534 KHz slot, RCVR #1)
6th Data Card:	0.0, 0.0, 0.0, 0.0, 0.0 (data for 534 KHz slot, RCVR #1)
7th Data Card	-11.5, -11.5, -11.5, -12.5, -14.5, -16.0, -18.5, -25.0, -32.5, -35.5 (data for 1248 KHz slot, RCVR #1)
8th Data Card	-41.0, -46.0, -51.0, -56.0, -61.0, -66.0, -70.0, -73.0, -75.0, -75.0 (data for 1248 KHz slot, RCVR #1)

9th Data Card: $\begin{cases} \text{0.0, 0.0, 0.0, 0.0, 0.0} \\ \text{(data for 1248 KHz slot, RCVR \#1)} \end{cases}$

Data cards for receiver number two must be organized in the same manner.

To summarize the last three sections, the data cards required to input the quieting curve data are:

a. One card to identify the number of input levels and slot information.

b. Three cards to enter the receiver signal levels at which SNR was measured.

c. Three cards to enter SNR measured in the low slot on receiver #1.

d. Three cards to enter SNR measured in the mid slot in receiver #1.

e. Three cards to enter SNR measured in the high slot on receiver #1.

f. Three cards to enter the SNR measured in the low slot on receiver #2.

g. Three cards to enter the SNR measured in the mid slot on receiver #2.

h. Three cards to enter the SNR measured in the high slot on receiver #2.

i. Three cards to enter the SNR measured in the low slot on receiver #3.

j. Three cards to enter the SNR measured in the mid slot on receiver #3.

k. Three cards to enter the SNR measured in the high slot on receiver #3.

l. Three cards to enter the SNR measured in the low slot on receiver #4.

m. Three cards to enter the SNR measured in the mid slot on receiver #4.

n. Three cards to enter the SNR measured in the high slot on receiver #4.

Only (a) is required if not data was measured on any receiver. Only cards (a) through (h) are required if only receivers were installed.

Measured Transmitter Frequency Accuracy Data-Specification Card. The following measured frequency accuracy data must be entered on this card:

1. Enter one of the following codes to identify how the transmitter frequency accuracy specification is specified:

a. Enter a 1.0 if the specification is to be entered as a percentage.

b. Enter a 2.0 if the specification is to be entered in terms of a frequency variation.

c. Enter a 0.0 if transmitter frequency accuracy data was not measured.

2. Enter the transmit frequency accuracy specification.

Some examples of data entries are given below:

a. Percentage--Assume the specification is given as 0.0005%. The data should be entered on the data card as: 1.0, 0.0005

b. Frequency Variation--Assume the specification is given as ± 30 KHz. The data should be entered on the data card as: 2.0, 30000.0.

c. Assume no data was measured. Enter 0.0, 0.0.

Measured Transmitter Frequency Accuracy Data Card. If no transmitter frequency accuracy data was measured, this card must not be included in the data deck. Otherwise, enter the following data on this data card:

1. Enter the frequency (MHz) measured on transmitter #1.

2. Enter the frequency (MHz) measured on transmitter #2.

Measured Local Oscillator Frequency Accuracy Data-Specification Card. Enter the following frequency accuracy specification data on this data card:

1. Enter one of the following codes to identify how the frequency accuracy specification will be entered:

a. Enter 1.0 if the specification will be entered as a percentage.

b. Enter 2.0 if the specification will be entered in terms of a frequency variation.

c. Enter a 0.0 if no local oscillator frequency accuracy

data was measured.

2. Enter the local oscillator frequency accuracy specification in the same manner as was described for transmitter frequency accuracy.

Measured Local Oscillator Frequency Accuracy Data-Assigned Frequency Data Card. This data card must not be included in the data deck if local oscillator frequency accuracy was not measured on any of the receivers. Otherwise, the following data must be entered on this card:

1. Enter the assigned local oscillator frequency (MHz) for receiver #1.

2. Enter the assigned local oscillator frequency (MHz) for receiver #2.

3. Enter the assigned local oscillator frequency (MHz) for receiver #3. Enter 0.0 if only two receivers were installed at the facility.

4. Enter the assigned local oscillator frequency (MHz) for receiver #4. Enter 0.0 if only two receivers were installed at the facility.

Measured Local Oscillator Frequency Accuracy Data Card. This card must not be included in the data deck if local oscillator frequency accuracy data was not measured on any of the receivers. Otherwise, enter the following data on this data card:

1. Enter the local oscillator frequency (MHz) measured on

receiver #1.

2. Enter the local oscillator frequency (MHz) measured on receiver #2.

3. Enter the local oscillator frequency (MHz) measured on receiver #3. Enter 0.0 if only two receivers were installed at the facility.

4. Enter the local oscillator frequency (MHz) measured on receiver #4. Enter 0.0 if only two receivers were installed at the facility.

Measured Link NPR Data-Configuration Data Card. Enter the following test configuration data on this data card:

1. Enter the number of tests performed at CCIR or DCA rated loading. The program is capable of handling up to eight different test configurations. If the link utilized diversity techniques and NPR tests were performed through the combiner and also on individual transmitter/receiver combinations, enter only the number of tests performed with the combiner in the configuration. Enter 0.0 if no link NPR tests were performed.

2. Enter one of the following codes to identify the type loading (DCA or CCIR) used to perform the link NPR tests:

a. 1.0 if CCIR loading was used,

b. 2.0 if DCA loading was used, or

c. 0.0 if no NPR tests were performed.

Measured Link NPR Data Card. If link NPR tests were not performed, do not include this data card in the data deck. One data card is required for each transmitter/receiver combination tested. If tests were performed through the combiner on diversity systems, enter only the NPR data measured in this manner. The following data is required on each data card, for each combination tested:

1. Enter the number (1.0-2.0) of the transmitter used in the test configuration. Enter a 5.0 if the input test point was the combiner on the transmit side.

2. Enter the number (1.0-4.0) of the receiver used in the test configuration. Enter a 5.0 if the output test point was the combiner test point on the receiver side.

3. Enter the measured low slot NPR (dB).

4. Enter the measured mid slot NPR (dB).

5. Enter the measured high slot NPR (dB).

6. Enter the measured low slot BNR (dB).

7. Enter the measured mid slot BNR (dB).

8. Enter the measured high slot BNR (dB).

Measured Multiplex NPR Data-Test Configuration Data Card. Enter one of the following codes on this data card to identify at which facilities multiplex NPR tests were performed:

1. 1.0 if multiplex NPR tests were performed at both facilities,

2. 2.0 if multiplex NPR tests were measured at the local facility (facility that this measured data applies to) only,

3. 3.0 if multiplex NPR tests were performed at the distant facility only, or

4. 0.0 if multiplex NPR tests were not performed at either facility.

Measured Multiplex NPR Data-Loading Level and Bandwidth Data Card. This data card must not be included in the data deck if multiplex NPRs were not measured at both facility. Otherwise, enter the following data on this data card:

1. Enter the loading level (dBmϕ) at which the multiplex NPR test was performed at the local facility. Enter 0.0 if no data was measured at the local facility.

2. Enter the upper baseband frequency (KHz) used in the noise test set to perform the multiplex NPR test at the local station. Enter 0.0 if no data was measured at the local facility.

3. Enter the lower baseband frequency (KHz) used in the noise test set to perform the multiplex NPR test at the local station. Enter 0.0 if no data was measured at the local facility.

4. Enter the loading level (dBmϕ) at which the multiplex NPR test was performed at the distant end facility. Enter 0.0 if no data was measured at the distant end facility.

5. Enter the upper baseband frequency (KHz) used in the noise test set to perform the multiplex NPR test at the distant end station. Enter 0.0 if no data was measured at the distant end facility.

6. Enter the lower baseband frequency (KHz) used in the noise

test set to perform the multiplex NPR test at the distant end station. Enter 0.0 if no data was measured at the distant end station.

Measured Multiplex NPR Data-Local Facility Measured Data. This data card must not be included in the data deck if multiplex NPR tests were not performed at the local facility. Otherwise, enter the following data on this data card:

1. Enter the multiplex NPR (dB) measured in the low slot at the local station. Enter 0.0 if NPR data was not measured in the low slot.

2. Enter the mutliplex NPR (dB) measured in the mid slot at the local station. Enter 0.0 if NPR data was not measured in the mid slot.

3. Enter the multiplex NPR (dB) measured in the high slot at the local station. Enter 0.0 if NPR data was not measured in the high slot.

4. Enter the multiplex BNR (dB) measured in the low slot at the local station. Enter 0.0 if BNR data was not measured in the low slot.

5. Enter the multiplex BNR (dB) measured in the mid slot at the local station. Enter 0.0 if BNR data was not measured in the mid slot.

6. Enter the multiplex BNR (dB) measured in the high slot at the local station. Enter 0.0 if BNR data was not measured in the high slot.

Measured Multiplex NPR Data-Distant Facility Measured Data. This data card must not be included in the data deck if multiplex NPR tests were not performed at the distant facility. Otherwise, enter the following data on this data card:

1. Enter the multiplex NPR (dB) measured in the low slot at the

distant station. Enter 0.0 if NPR data was not measured in the low slot.

2. Enter the multiplex NPR (dB) measured in the mid slot at the distant station. Enter 0.0 if no NPR data was measured in the mid slot.

3. Enter the multiplex NPR (dB) measured in the high slot at the distant station. Enter 0.0 if NPR data was not measured in the high slot.

4. Enter the multiplex BNR (dB) measured in the low slot at the distant station. Enter 0.0 if BNR data was not measured in the low slot.

5. Enter the multiplex BNR (dB) measured in the mid slot at the distant station. Enter 0.0 if BNR data was not measured in the mid slot.

6. Enter the multiplex BNR (dB) measured in the high slot at the distant station. Enter 0.0 if BNR data was not measured in the high slot.

Path Parameters and Equipment Specifications--Station Number Two

The path parameters and equipment specifications for station #2 must be entered in the same manner as described for station #1.

Measured Data Inputs-Station Number Two

The data parameters measured at station #2 must be entered in

the same manner as described for station #2.

Organization of the Data Deck

The data card deck must be organized as shown in Fig. 7 on the next page.

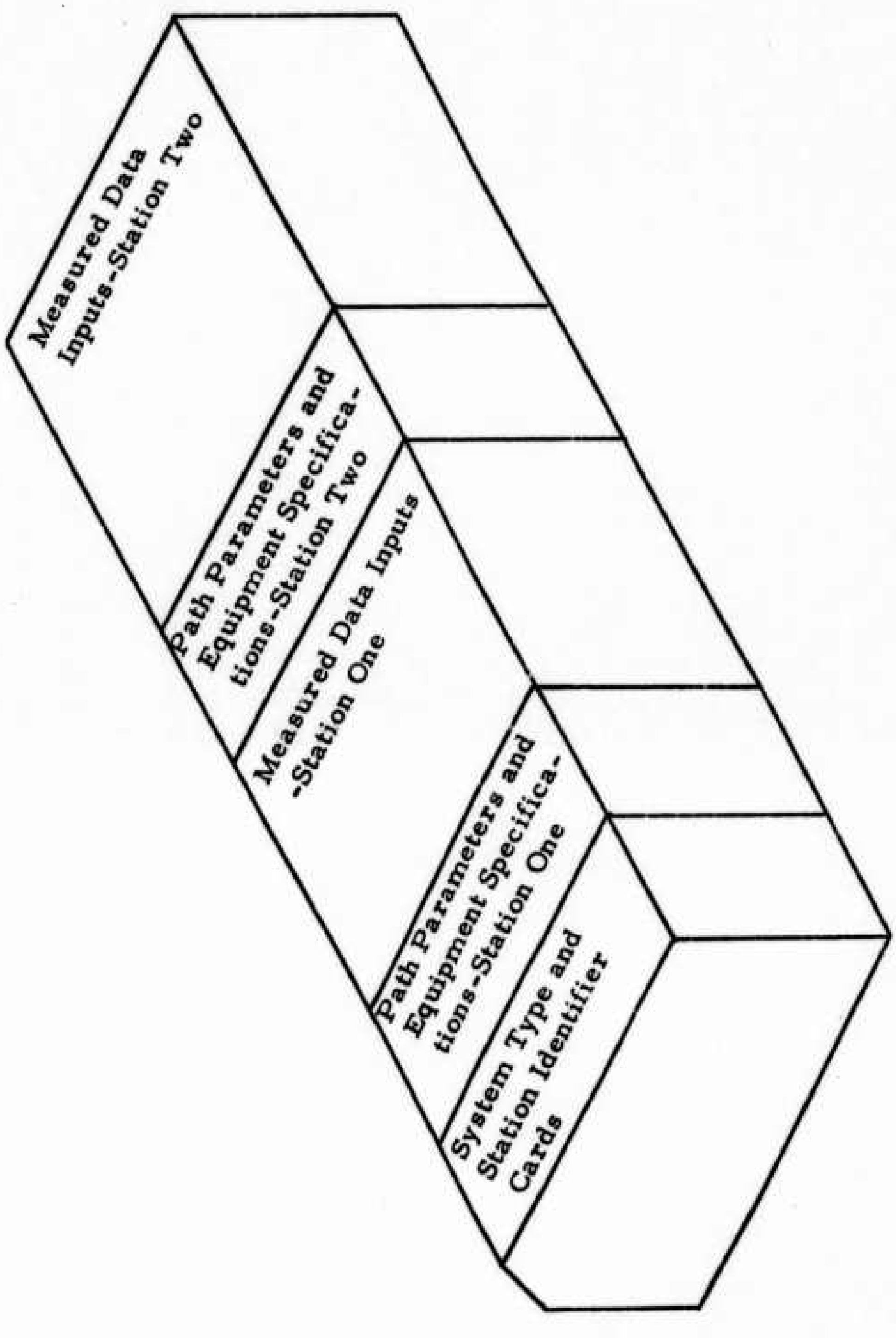

Fig. 7. Organization of Data Deck

Appendix B

Program Flow Charts

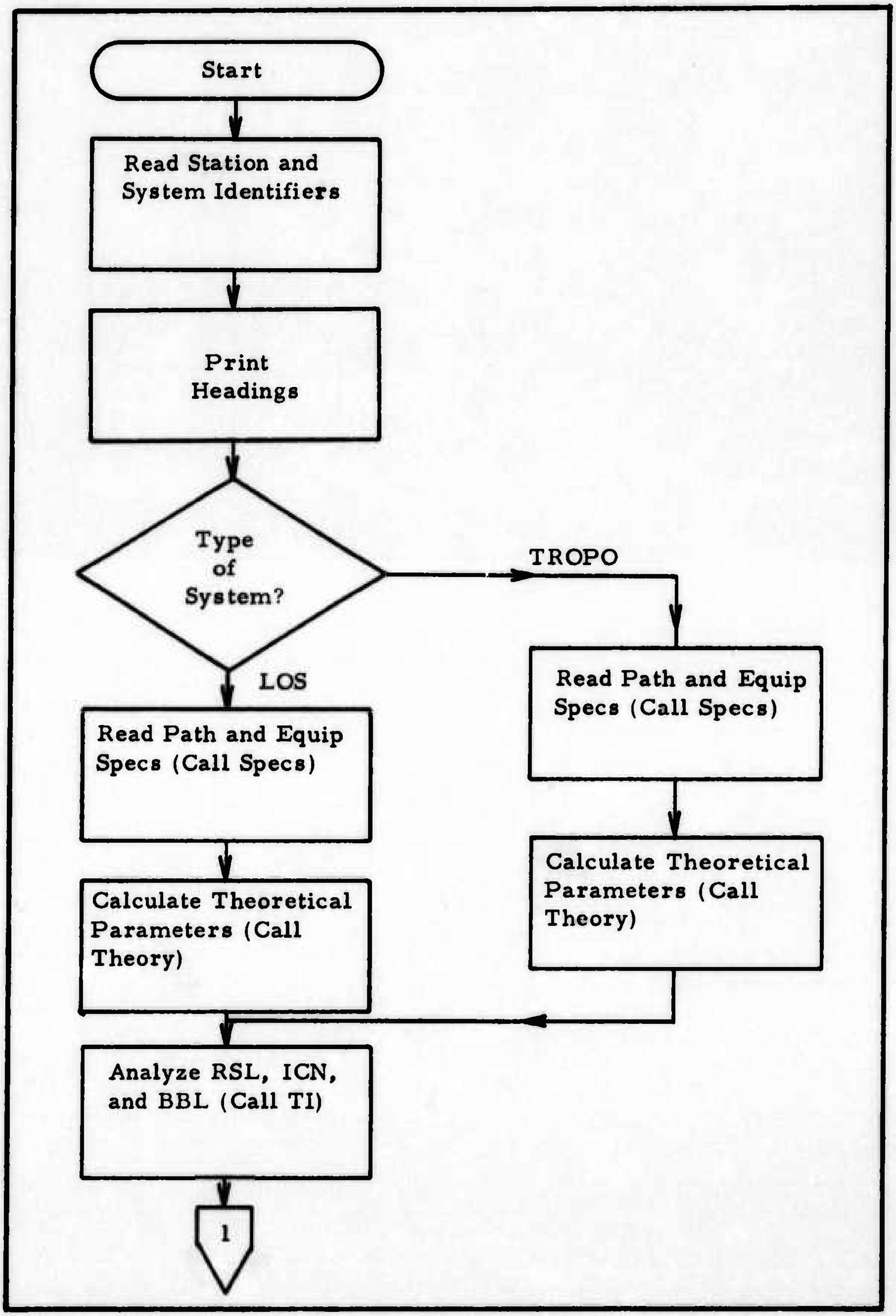

Fig. 8. Main Program

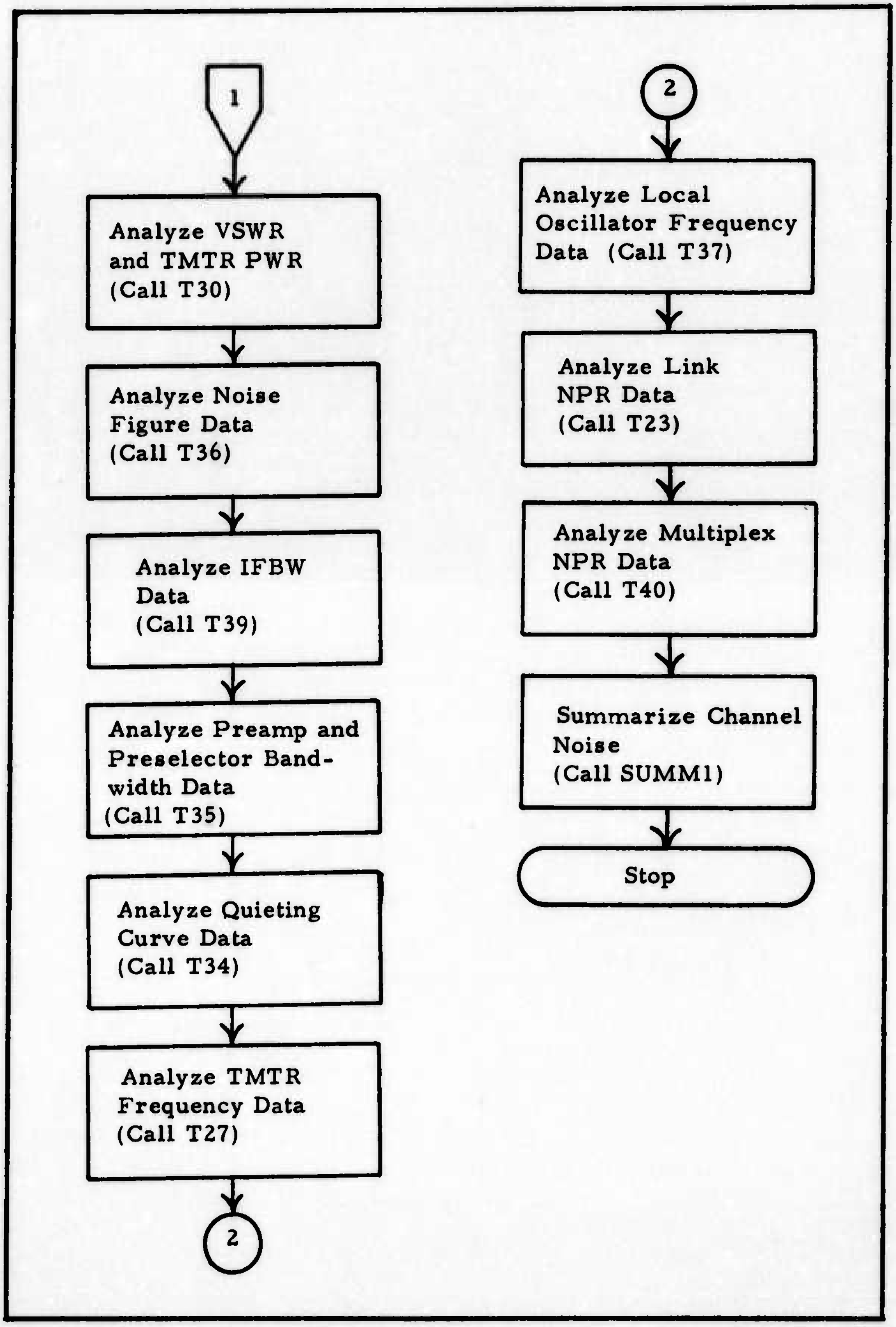

Fig. 9. Main Program (cont)

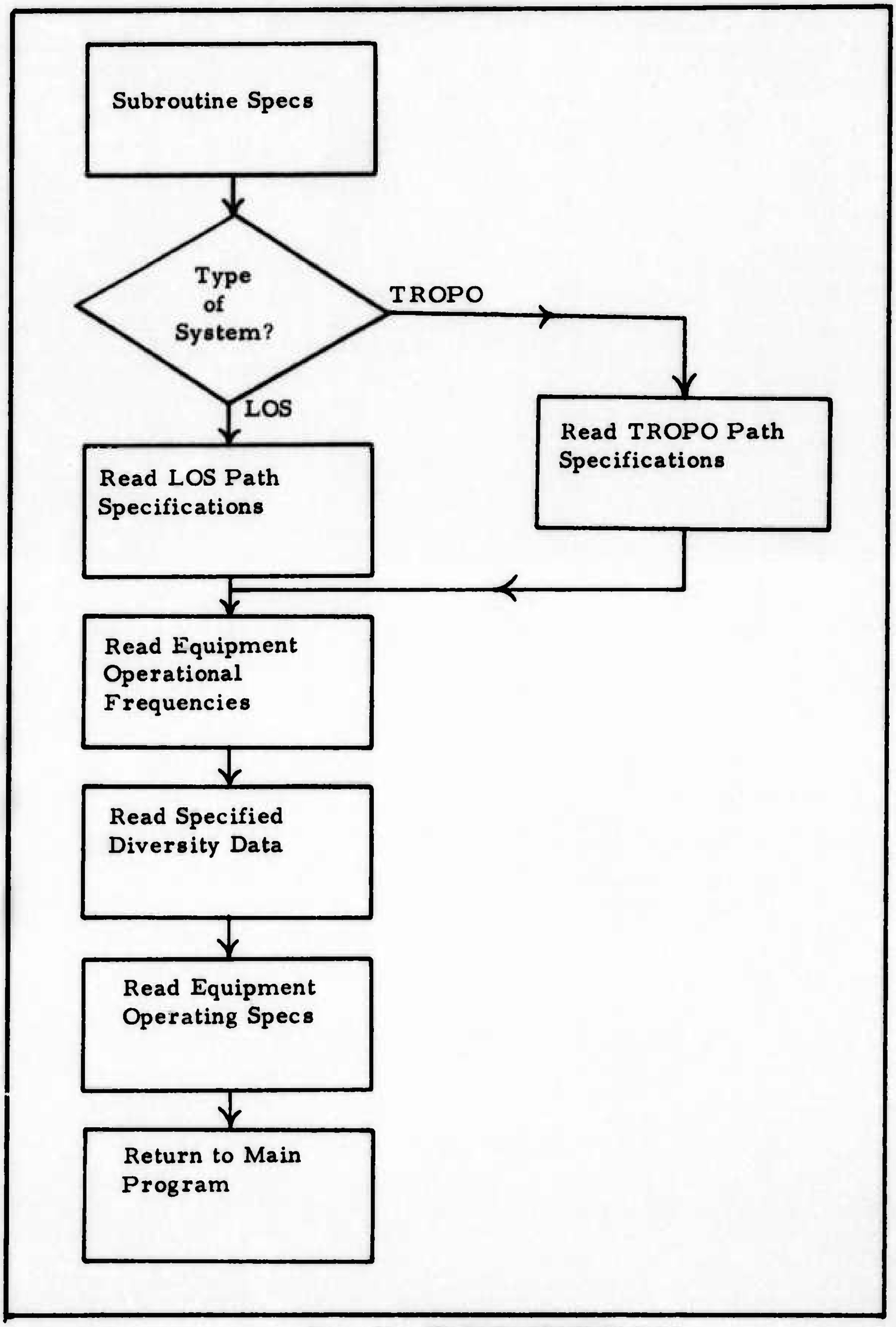

Fig. 10. SUBROUTINE SPECS

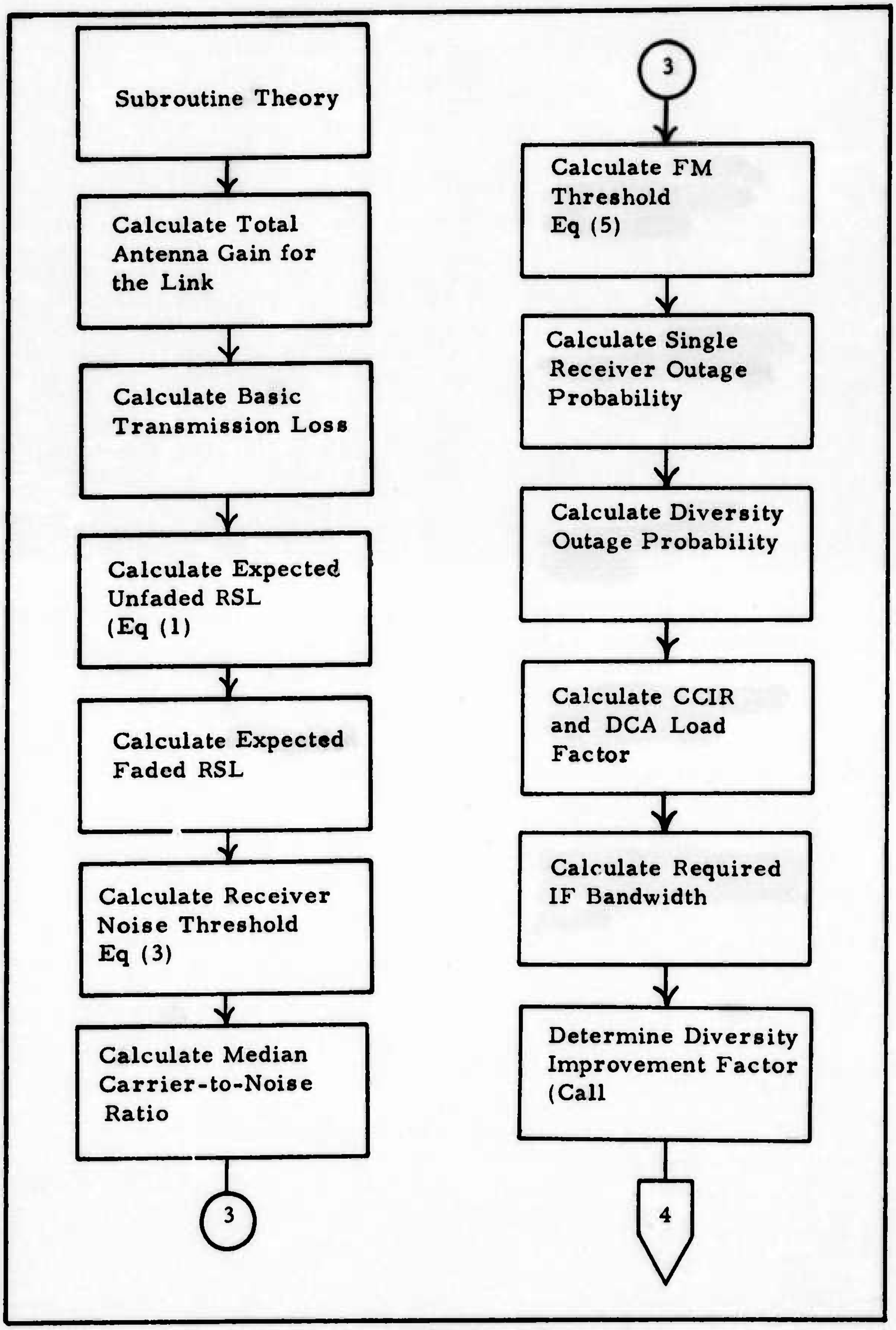

Fig. 11. SUBROUTINE THEORY

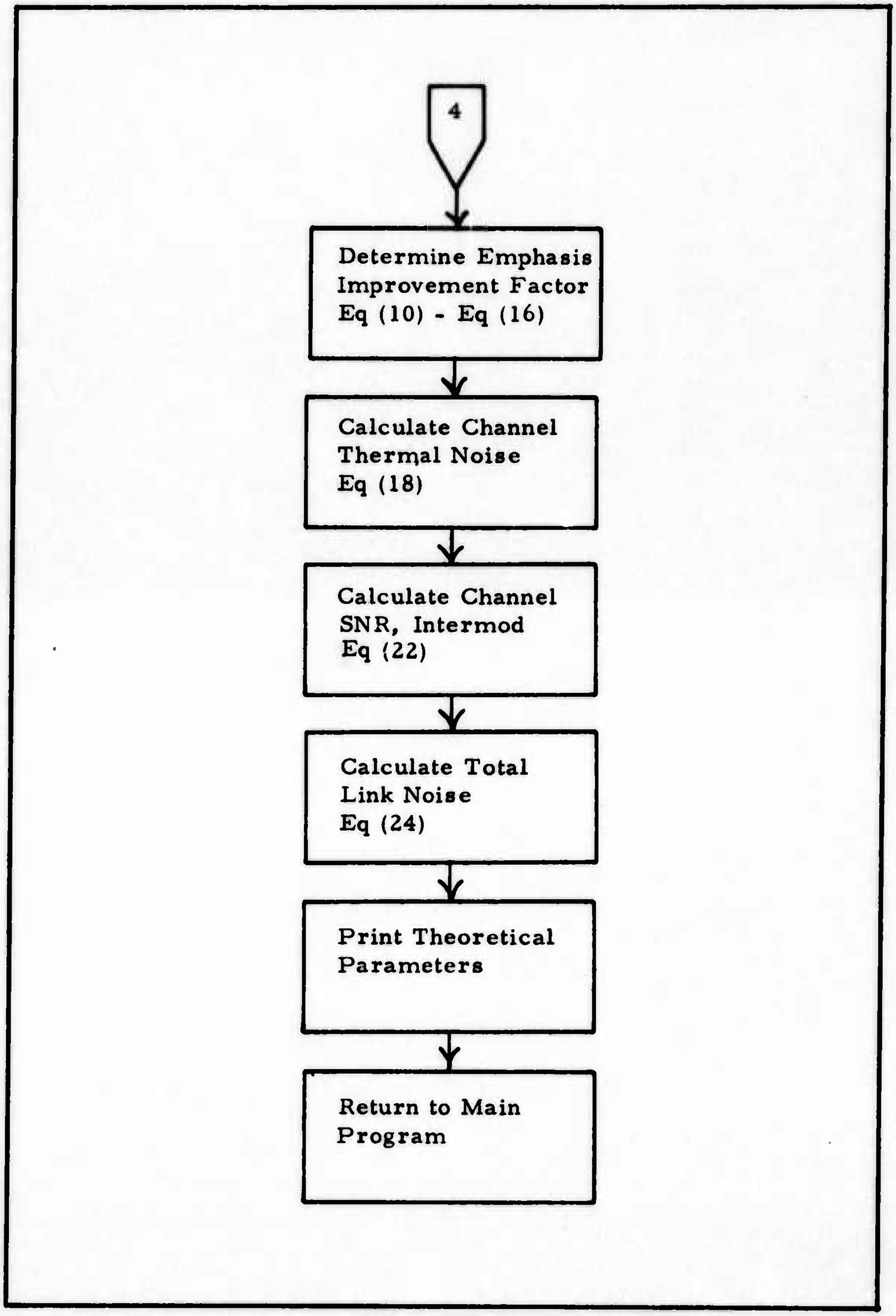

Fig. 12. SUBROUTINE THEORY (cont.)

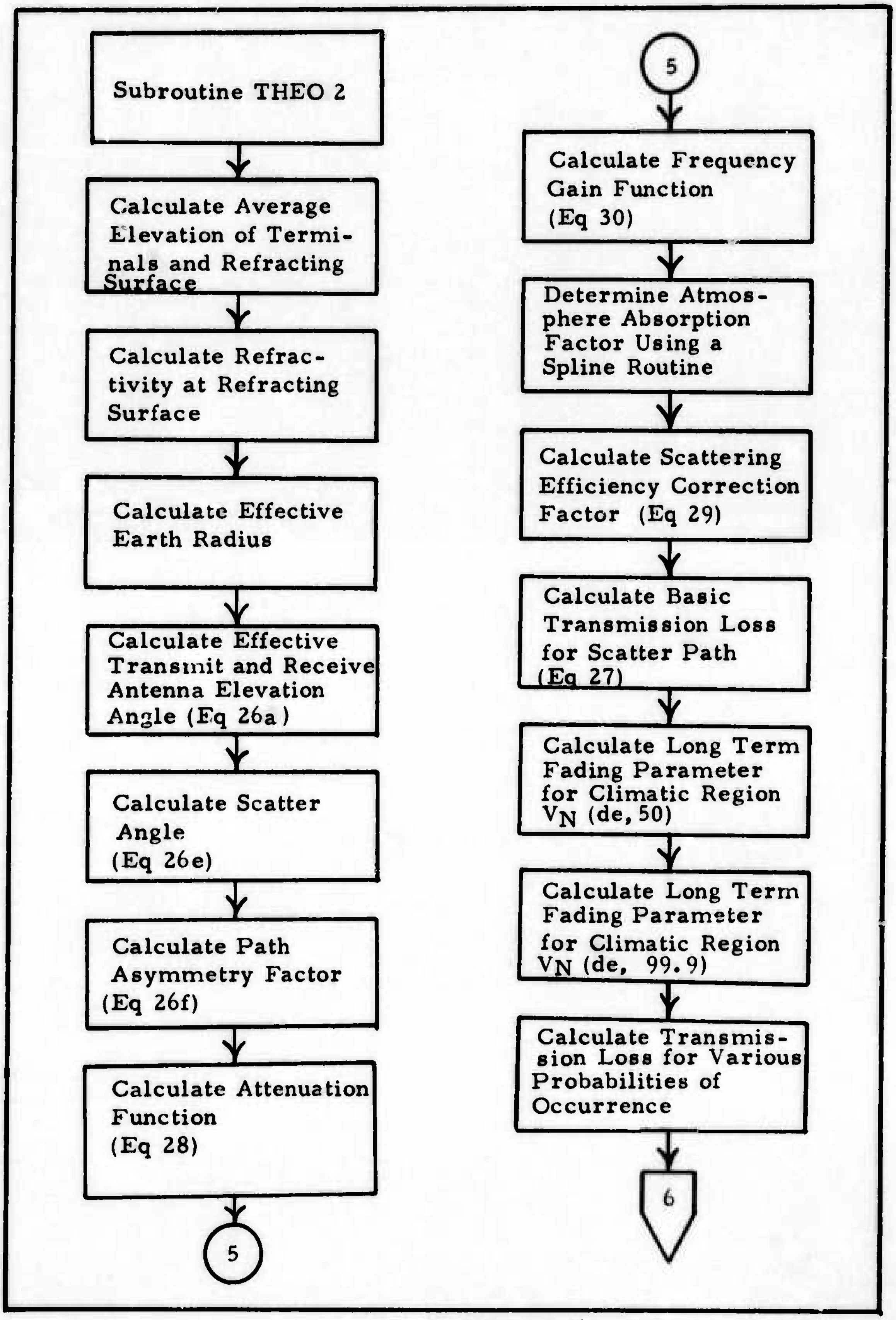

Fig. 13. SUBROUTINE THEO 2

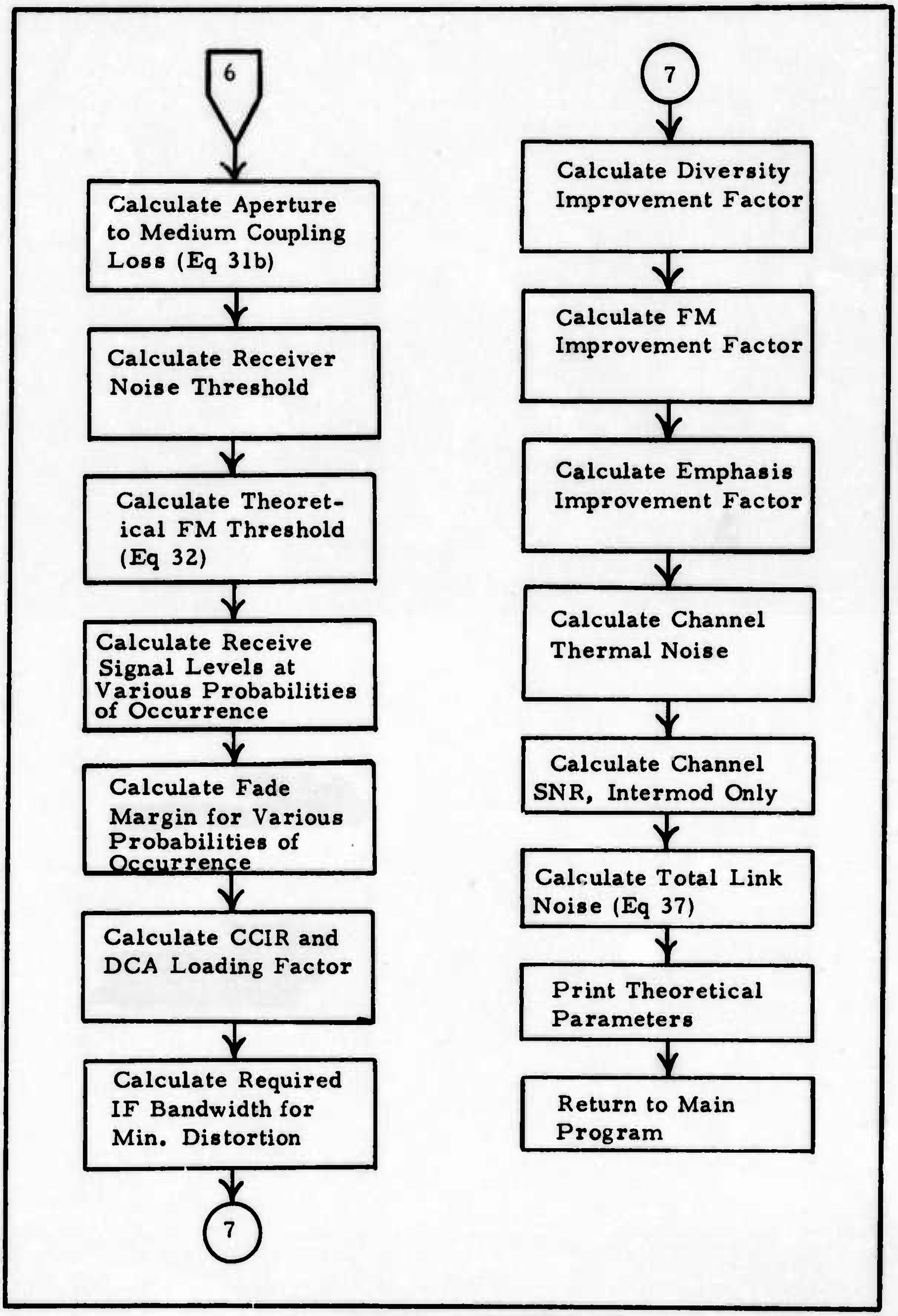

Fig. 14. SUBROUTINE THEO 2 (cont)

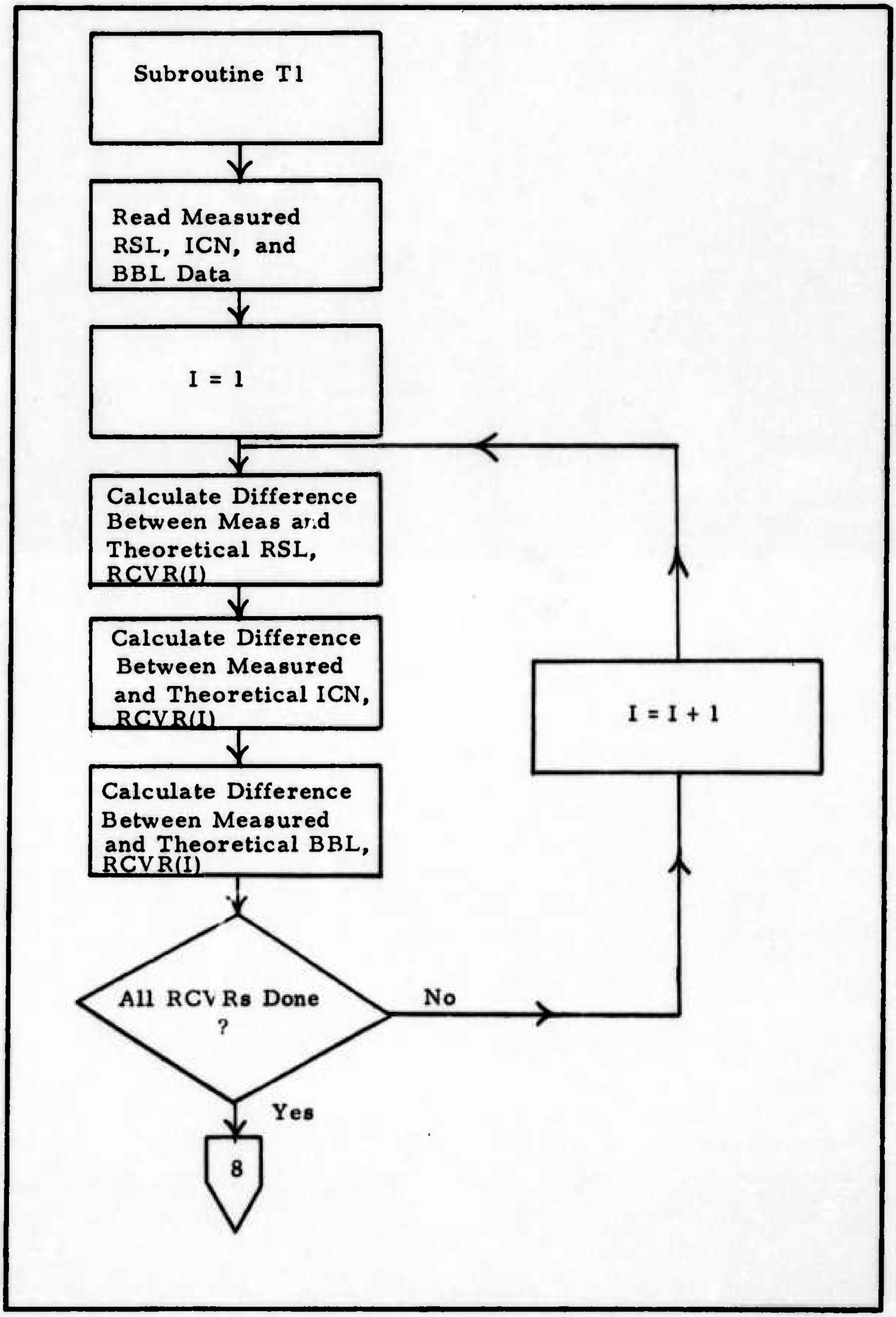

Fig. 15. SUBROUTINE T1

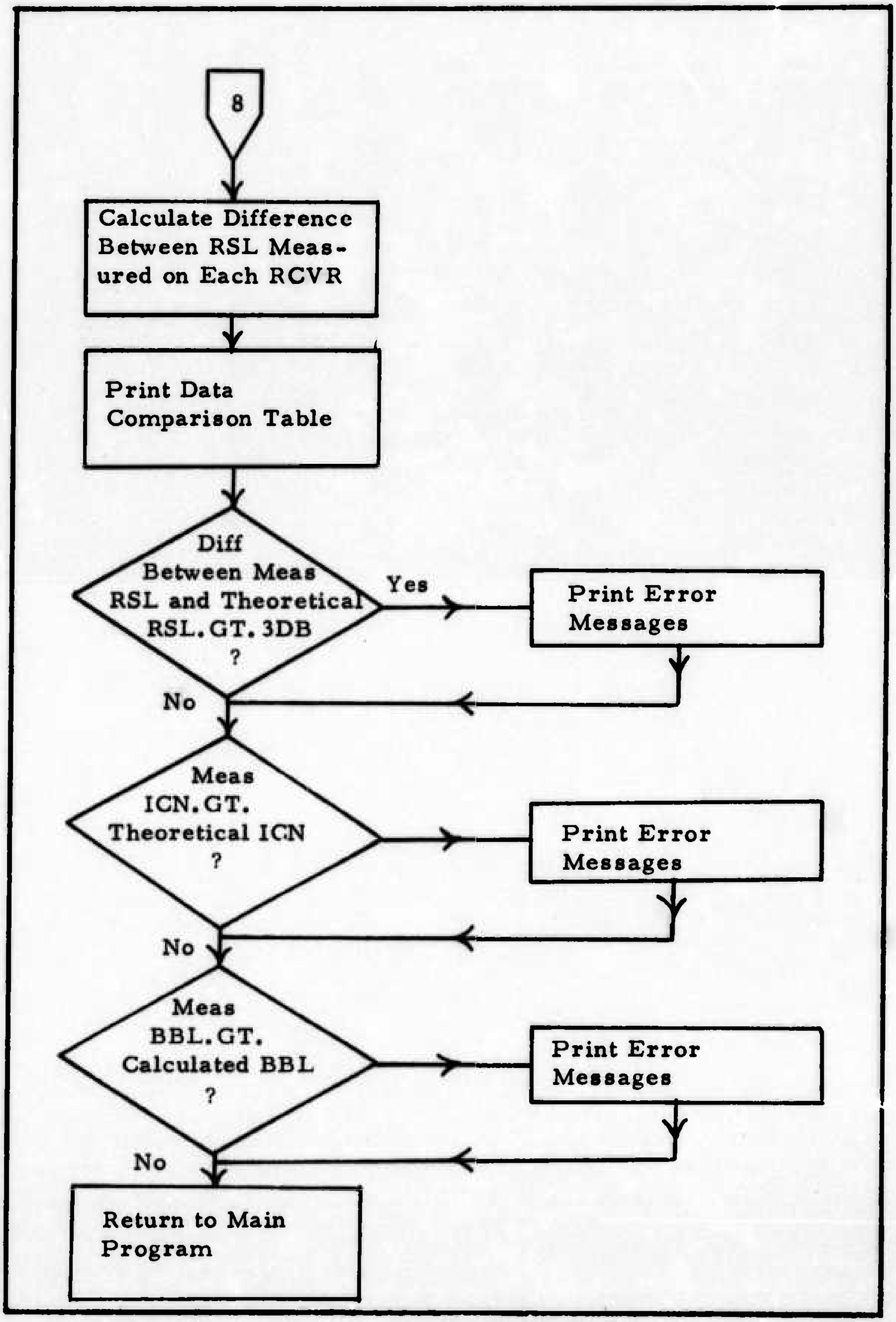

Fig. 16. SUBROUTINE T1 (cont)

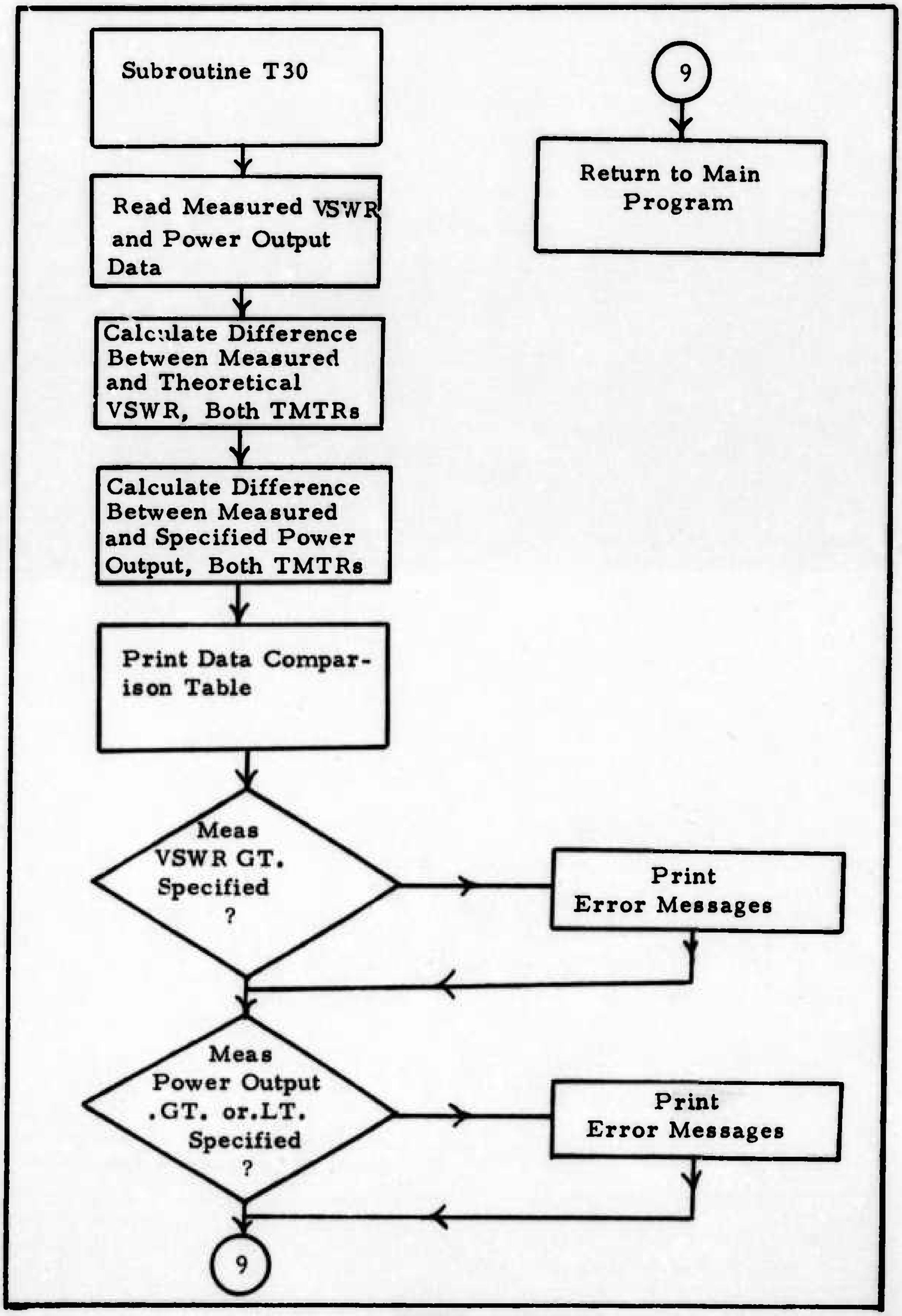

Fig. 17. SUBROUTINE T30

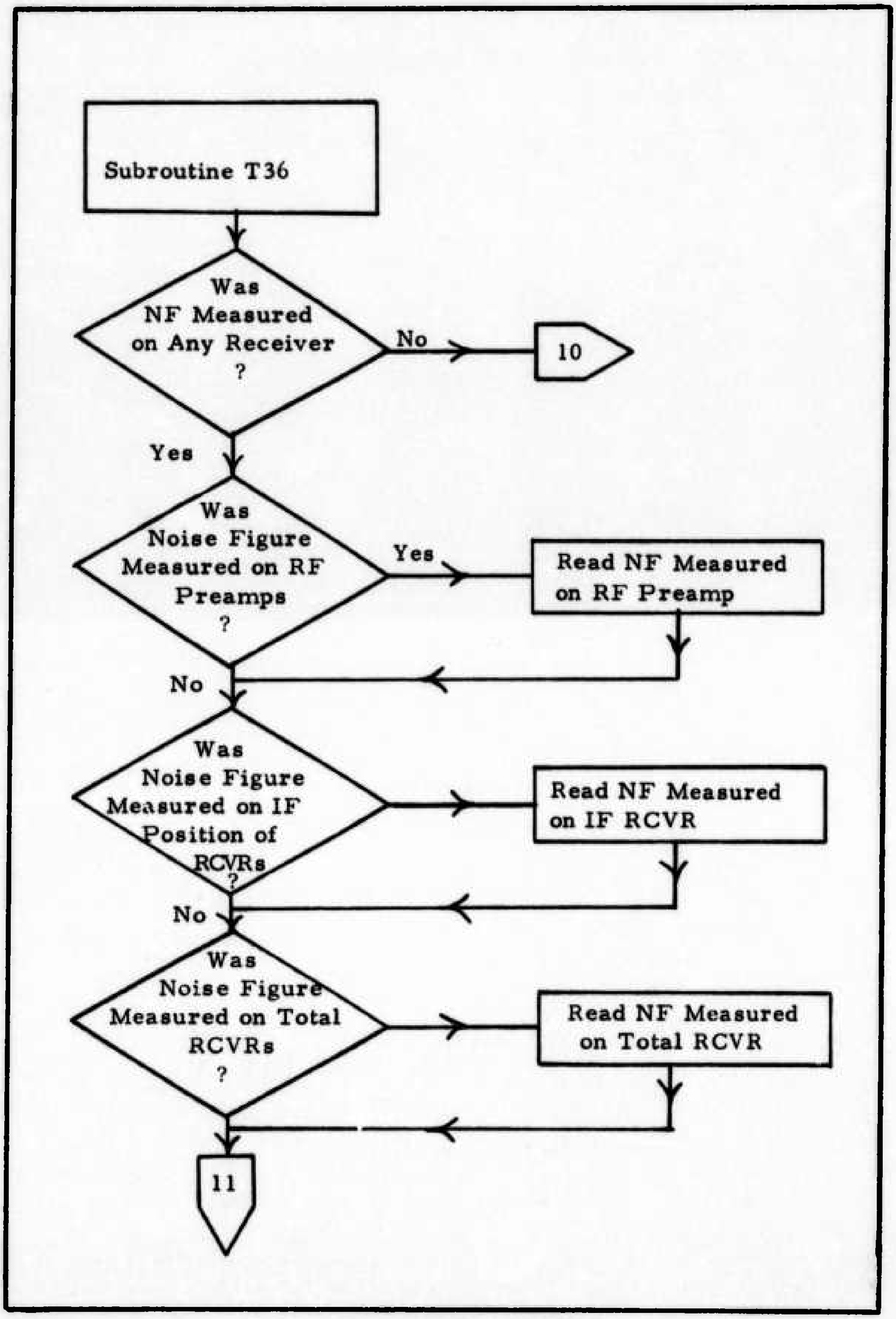

Fig. 18. SUBROUTINE T36

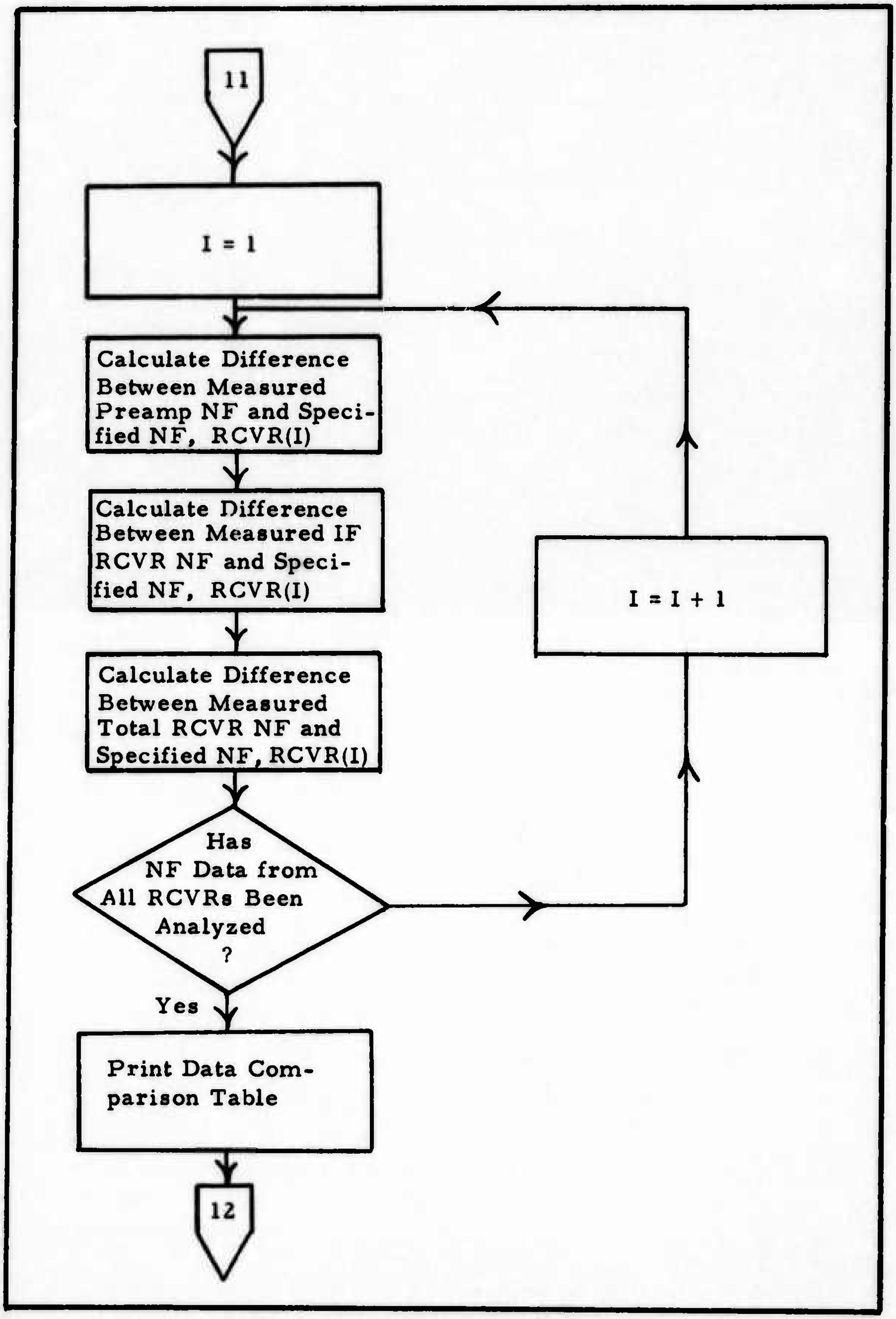

Fig. 19. SUBROUTINE T36 (cont)

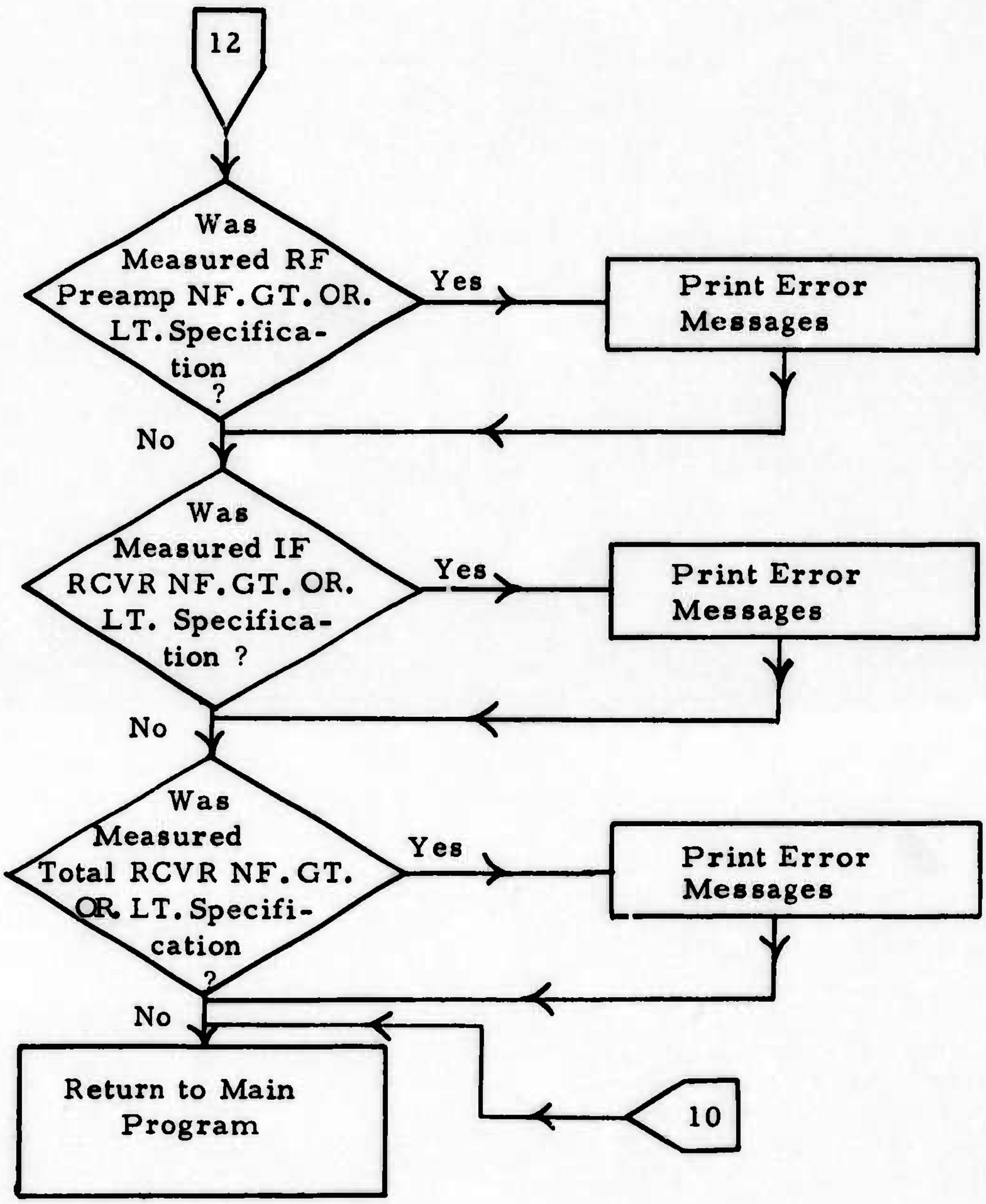

Fig. 20. SUBROUTINE T36 (cont)

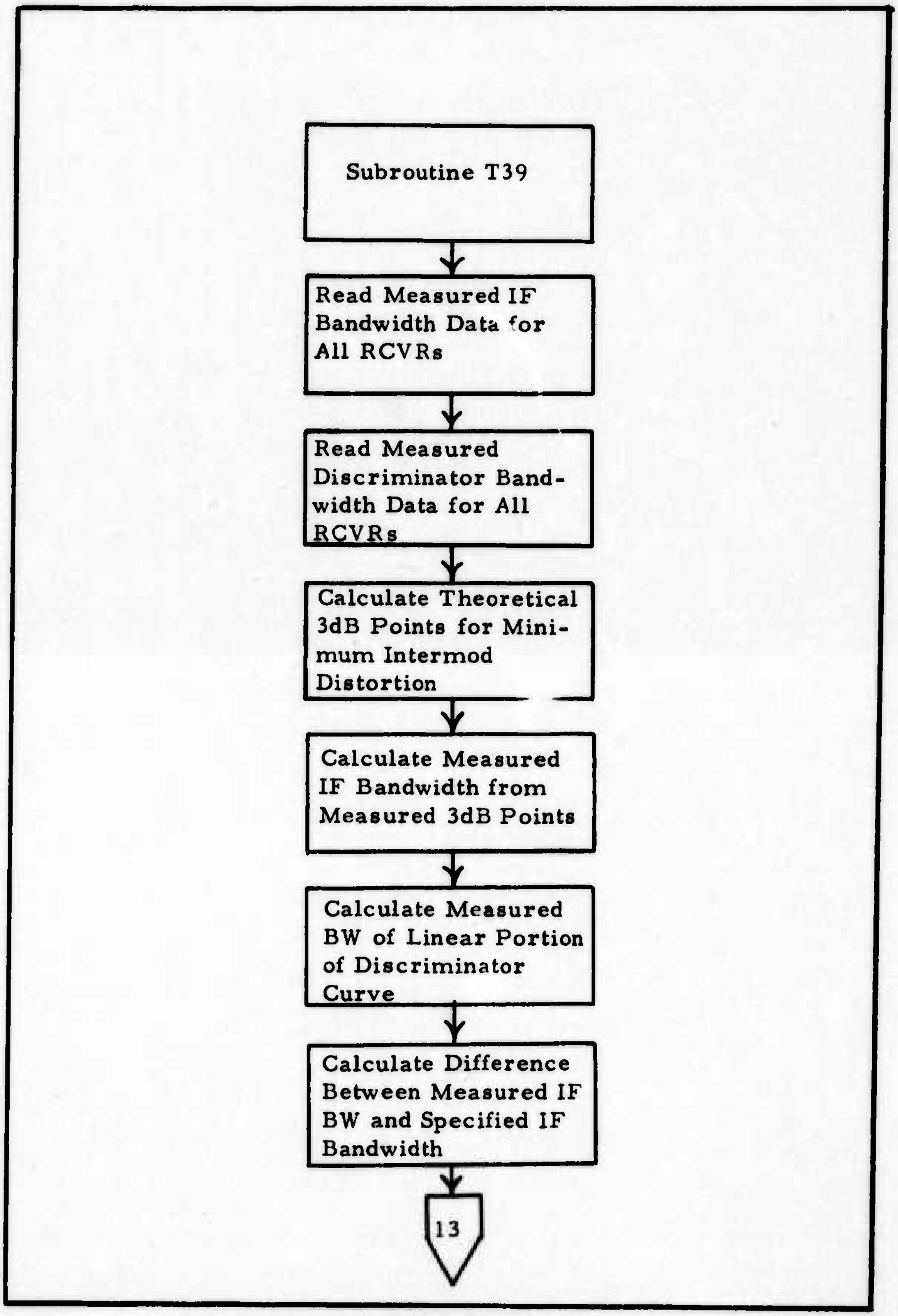

Fig. 21. SUBROUTINE T39

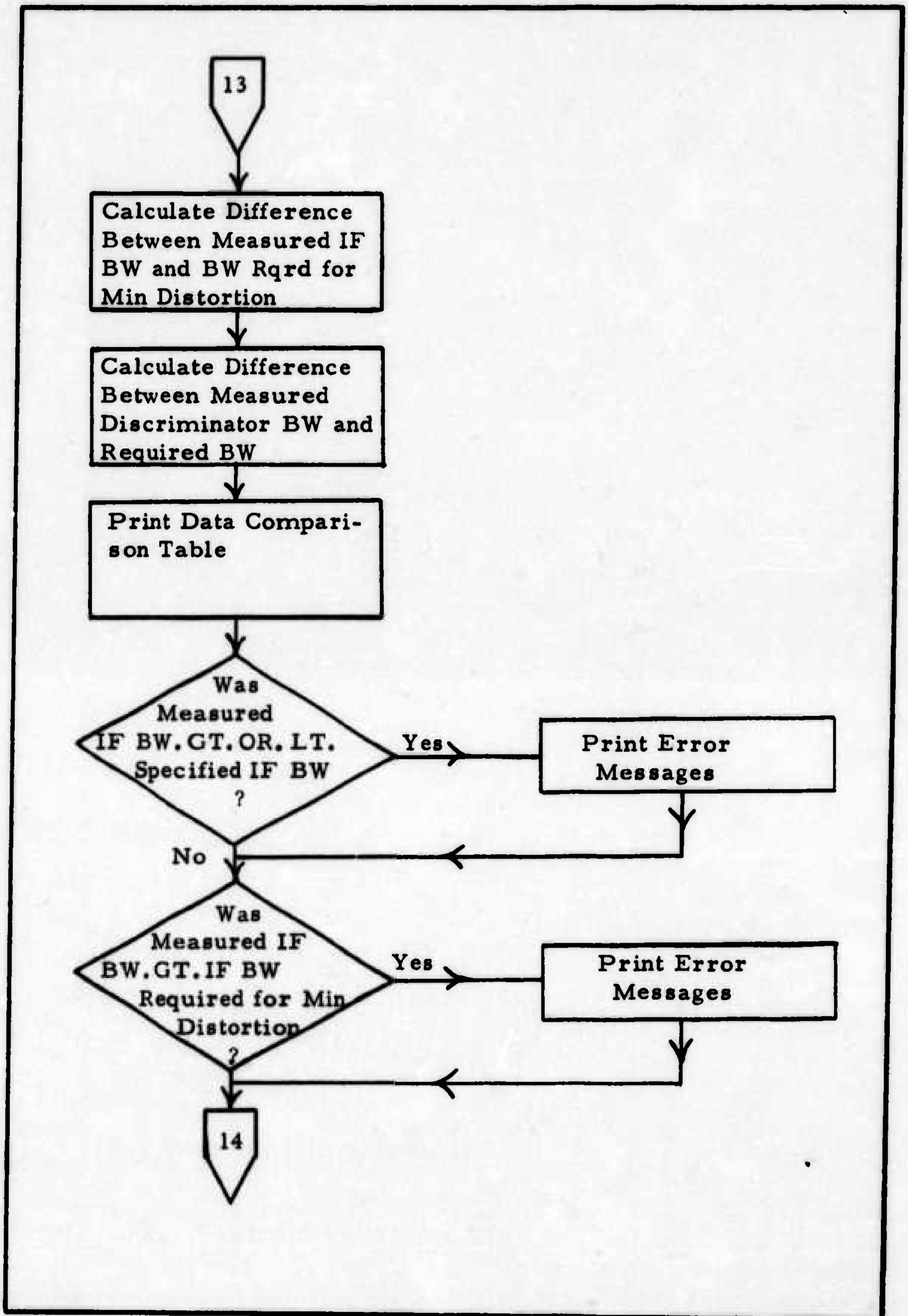

Fig. 22. SUBROUTINE T39 (cont)

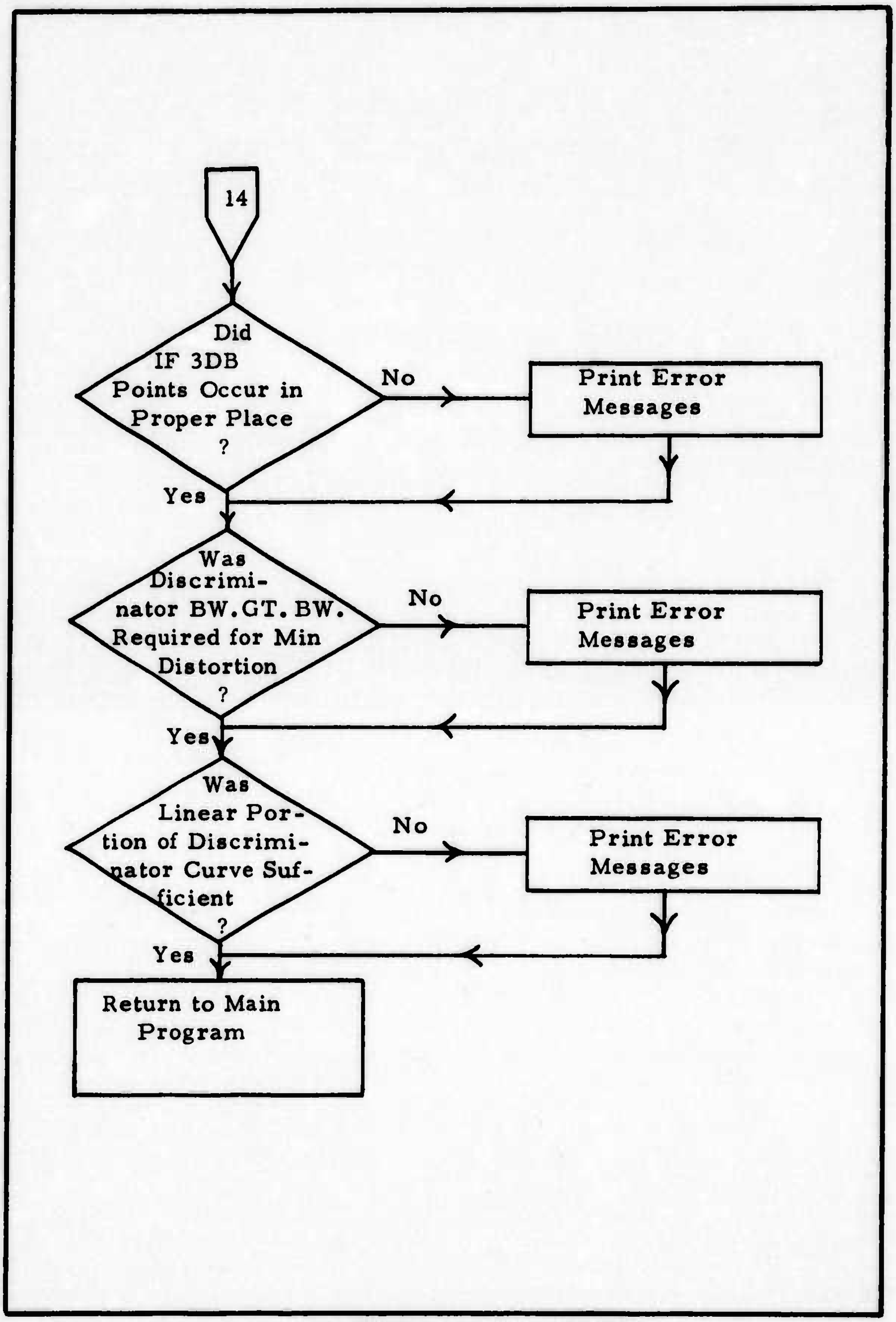

Fig. 23. SUBROUTINE T39 (cont)

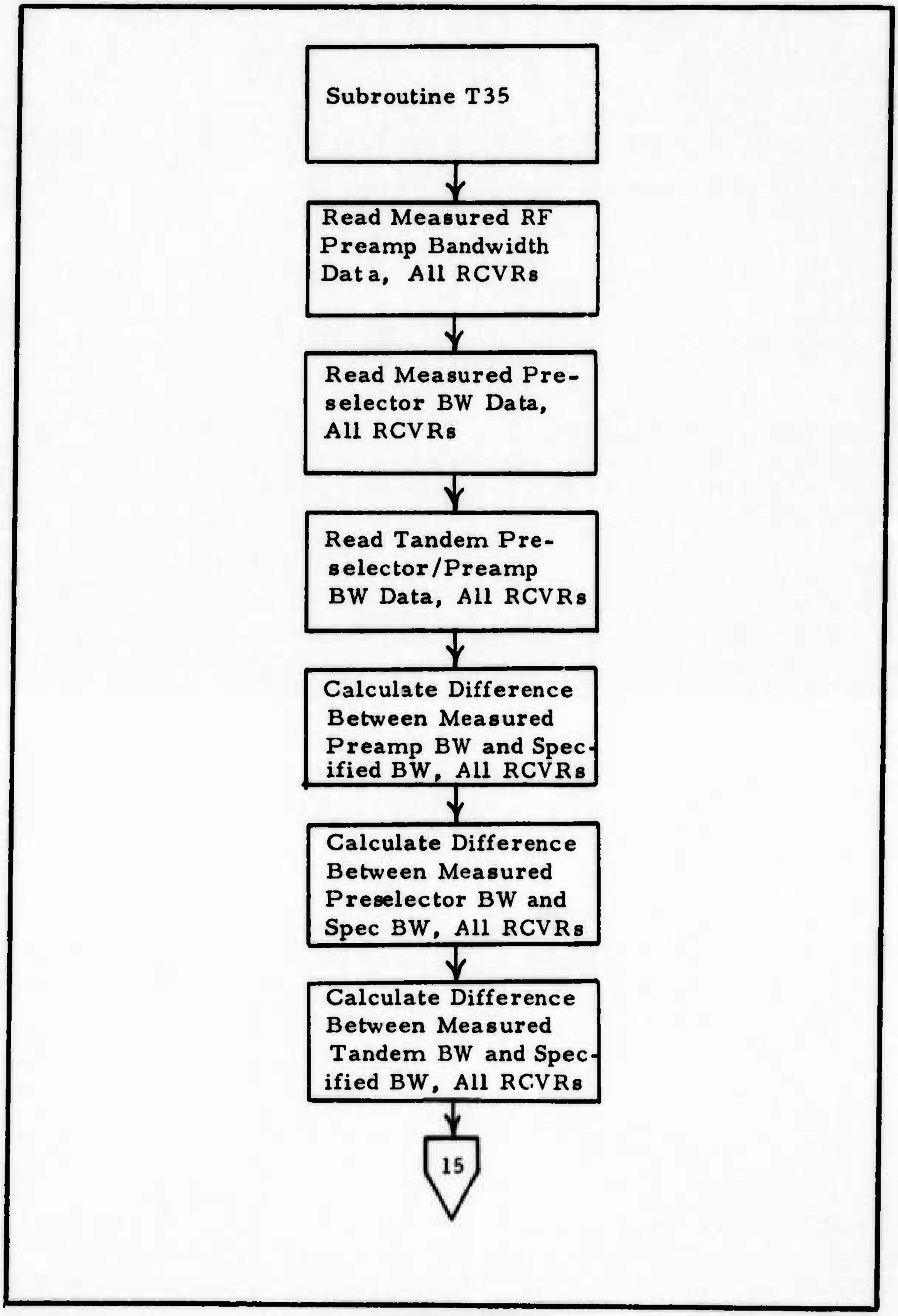

Fig. 24. SUBROUTINE T35

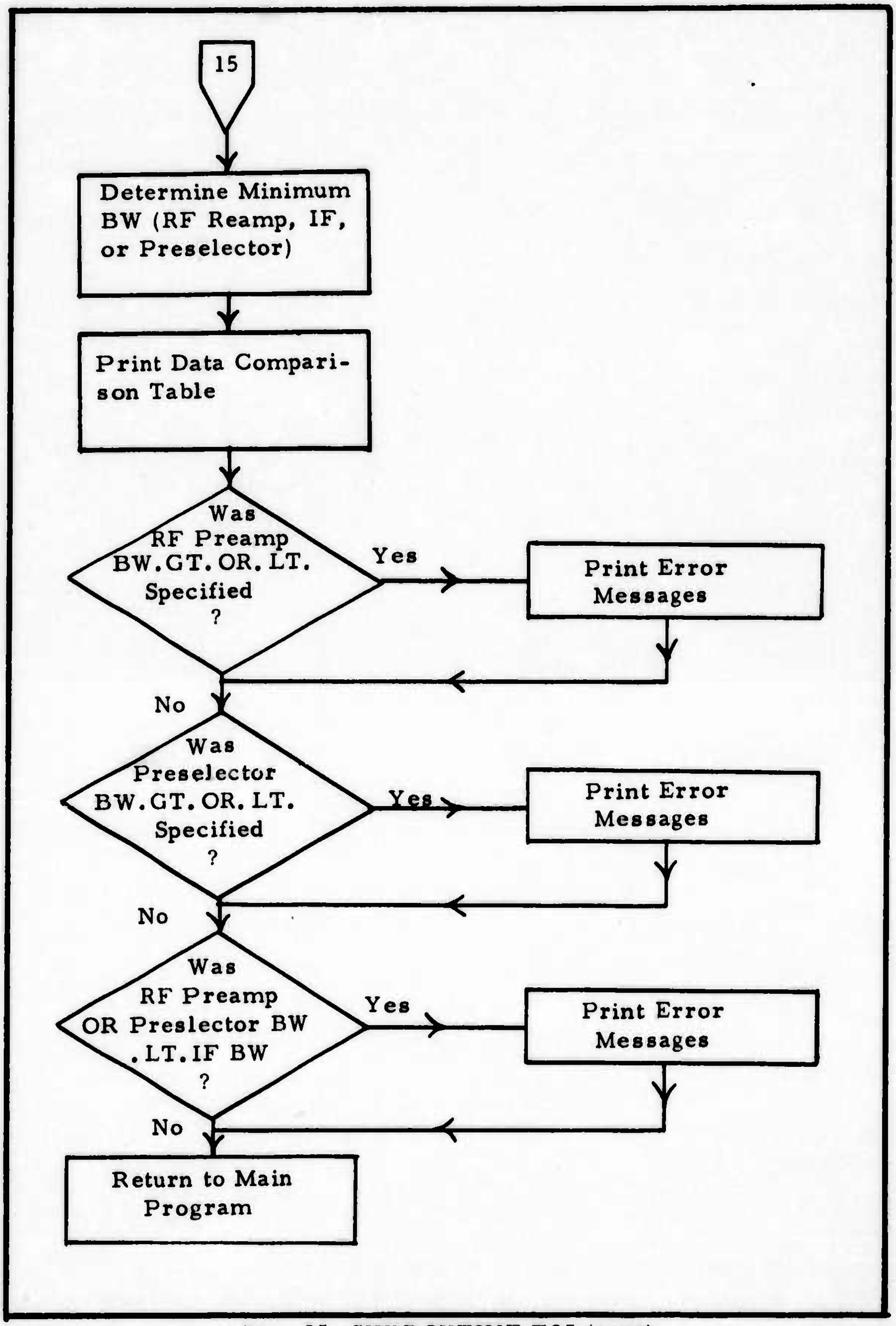

Fig. 25. SUBROUTINE T35 (cont)

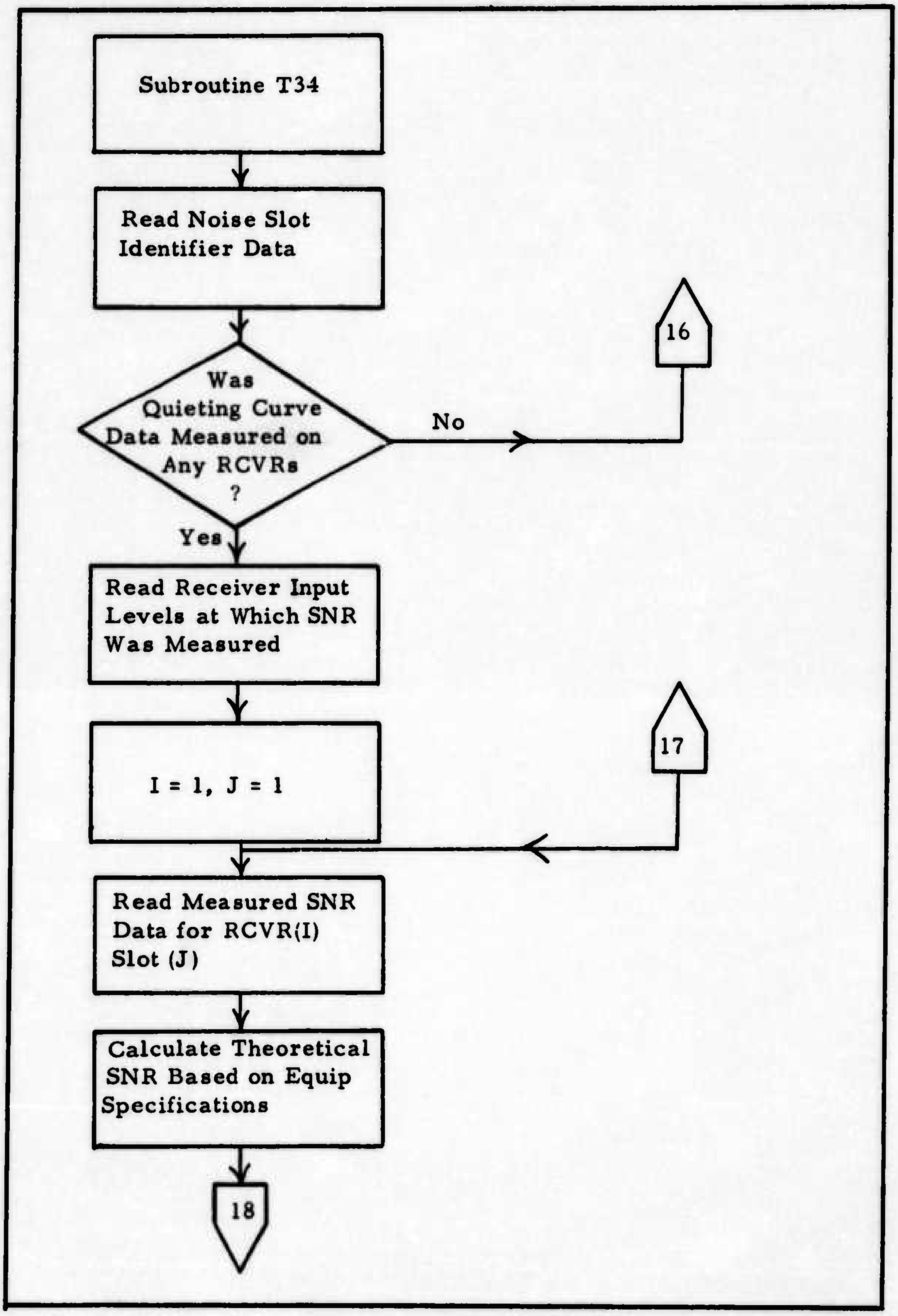

Fig. 26. SUBROUTINE T34

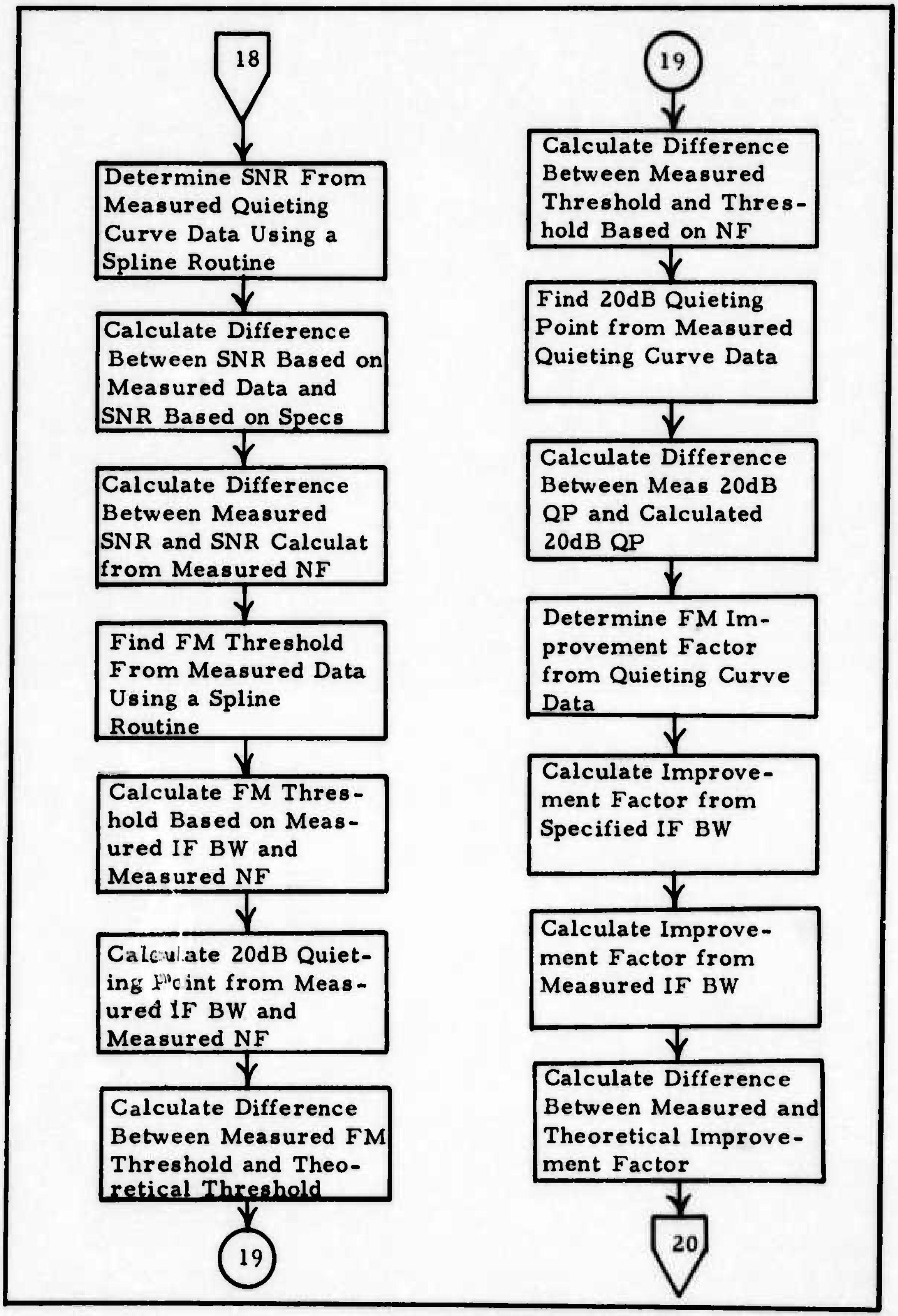

Fig. 27. SUBROUTINE T34 (cont)

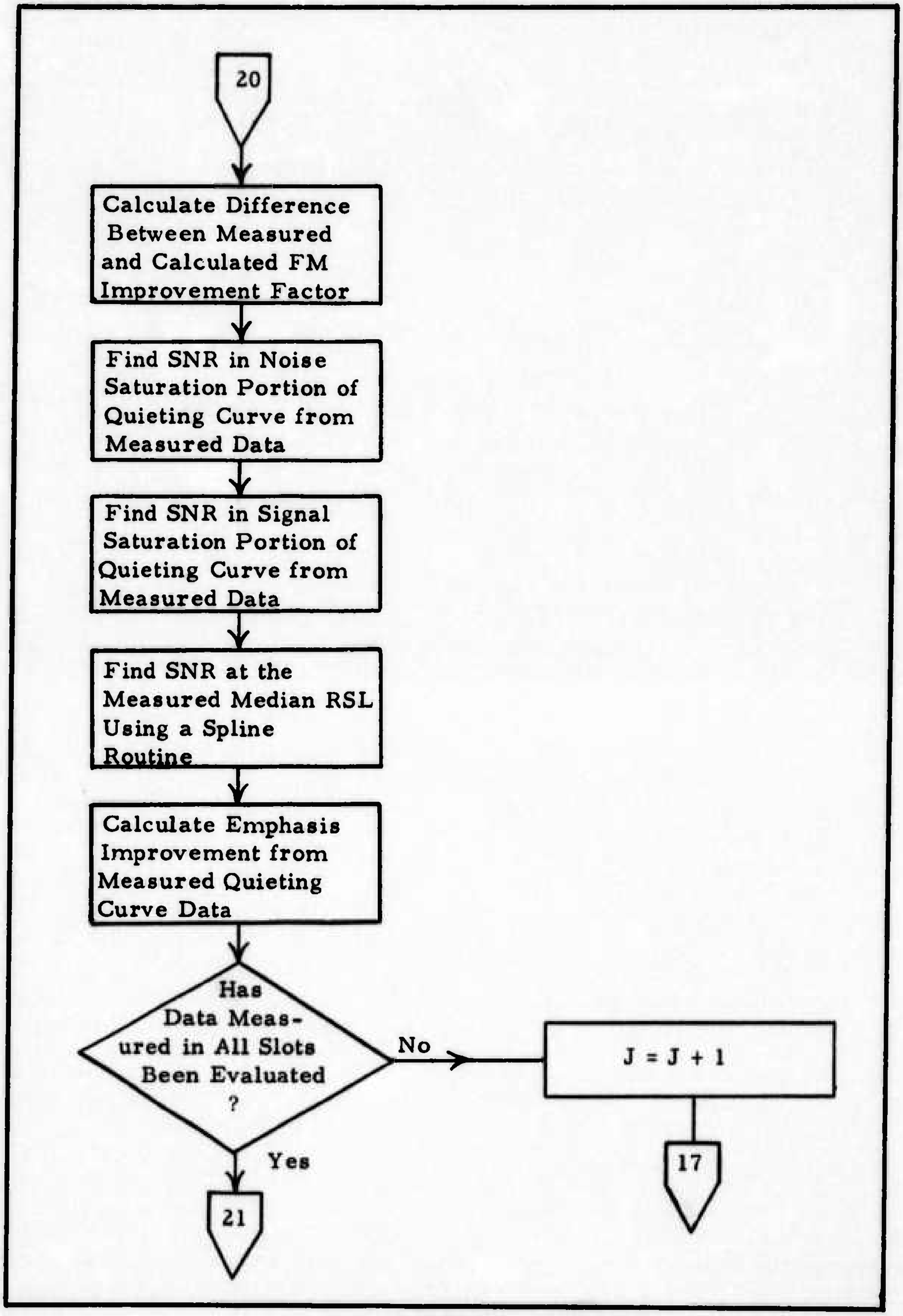

Fig. 28. SUBROUTINE T34 (cont)

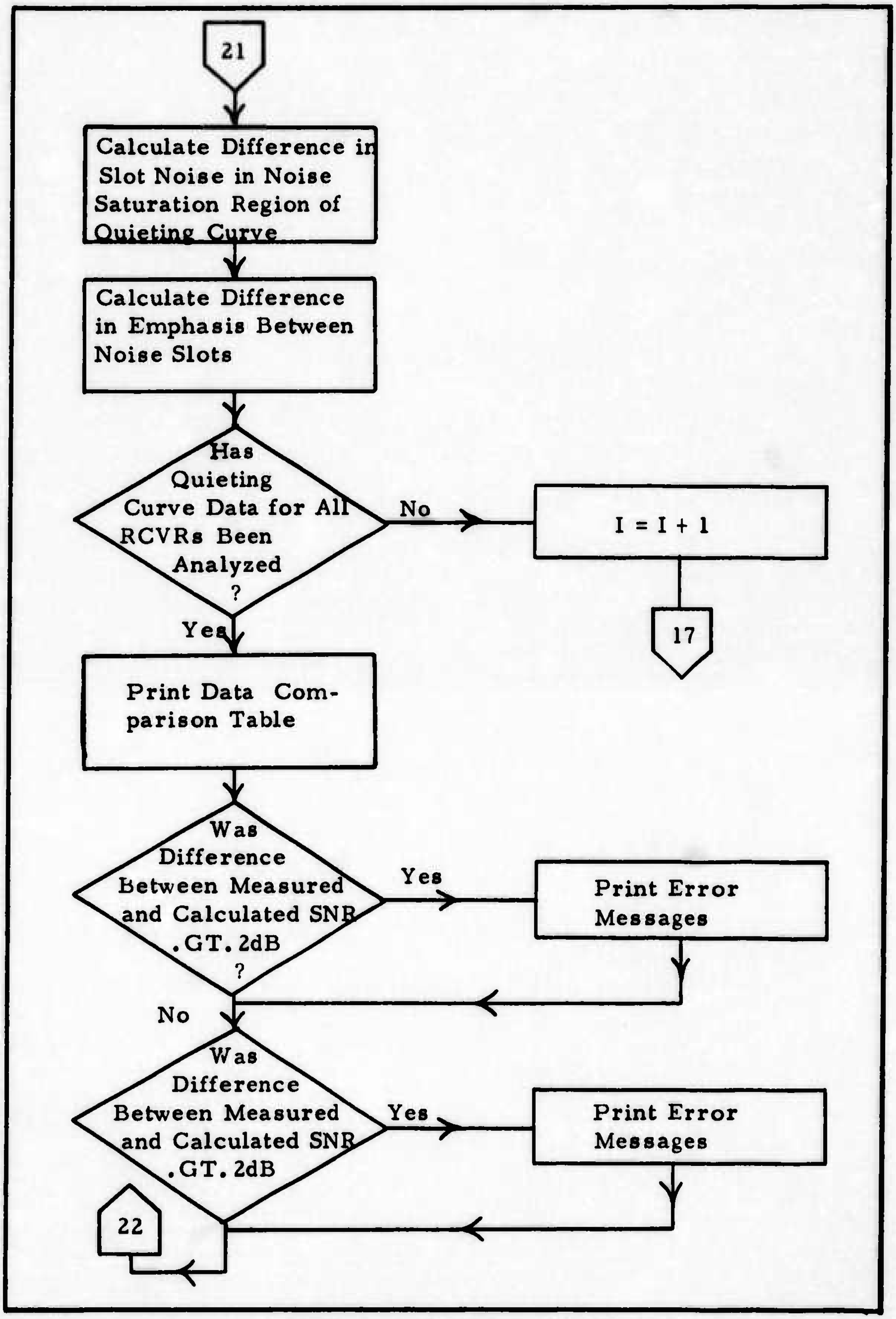

Fig. 29, SUBROUTINE T34 (cont)

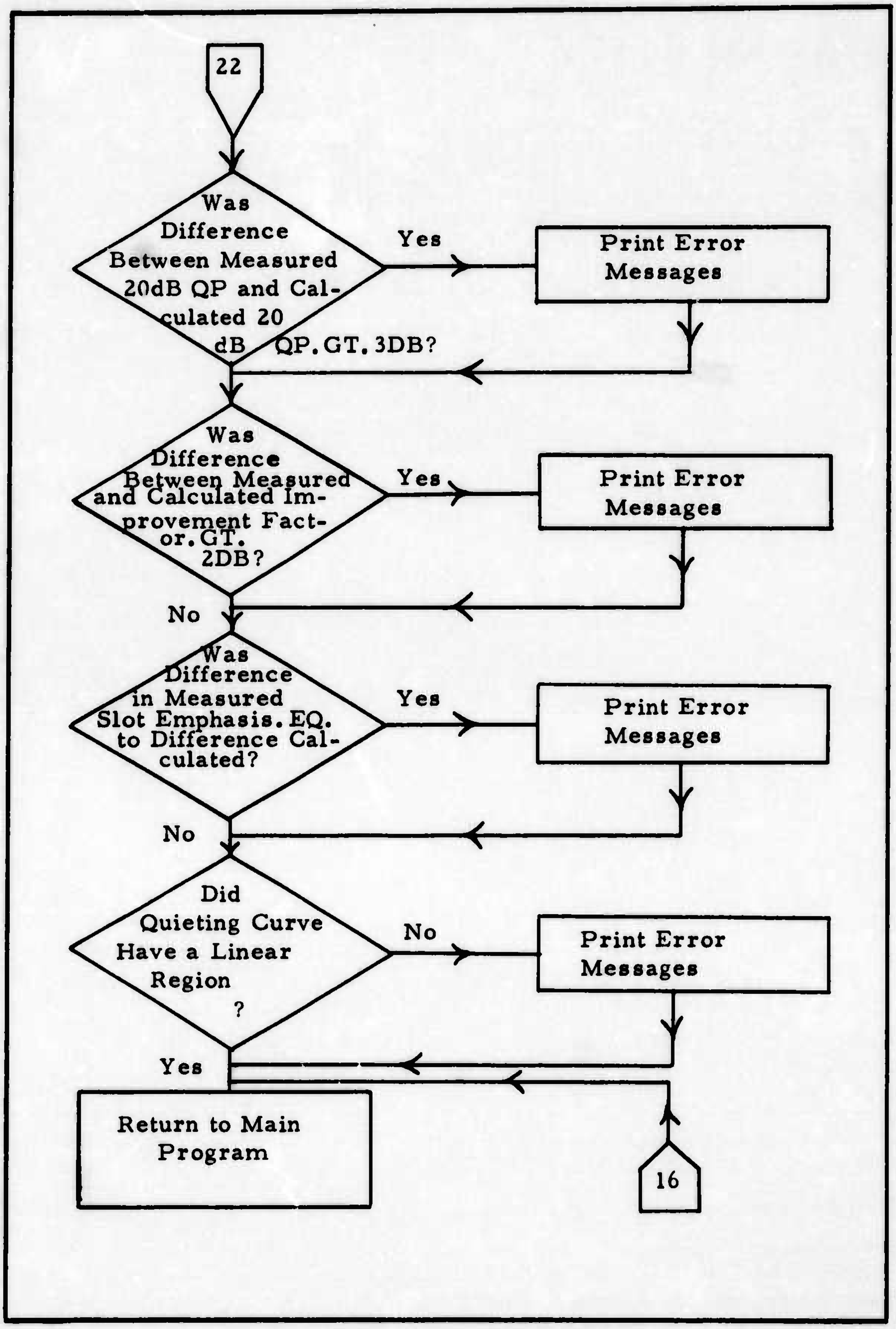

Fig. 30. SUBROUTINE T34 (cont)

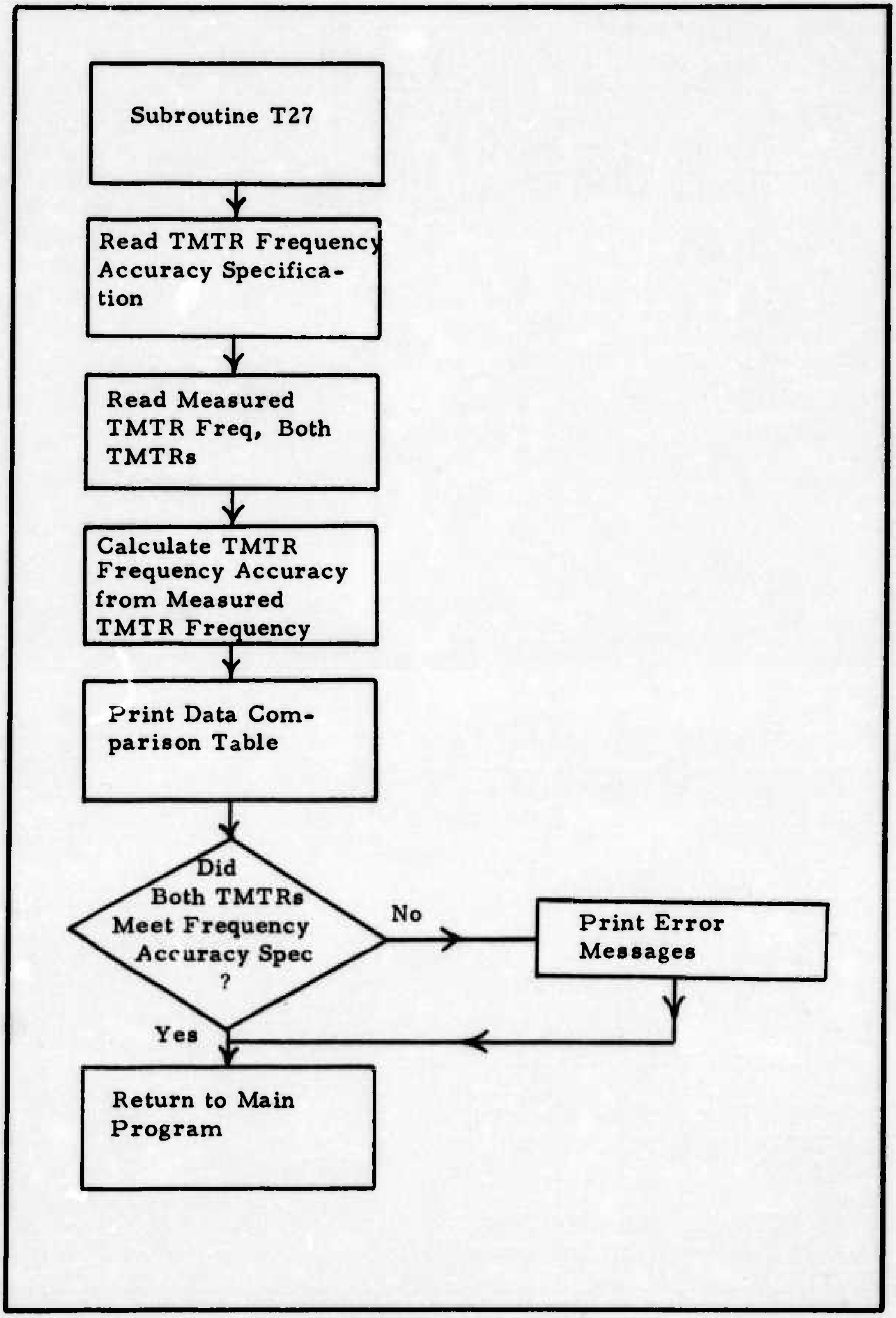

Fig. 31. SUBROUTINE T27

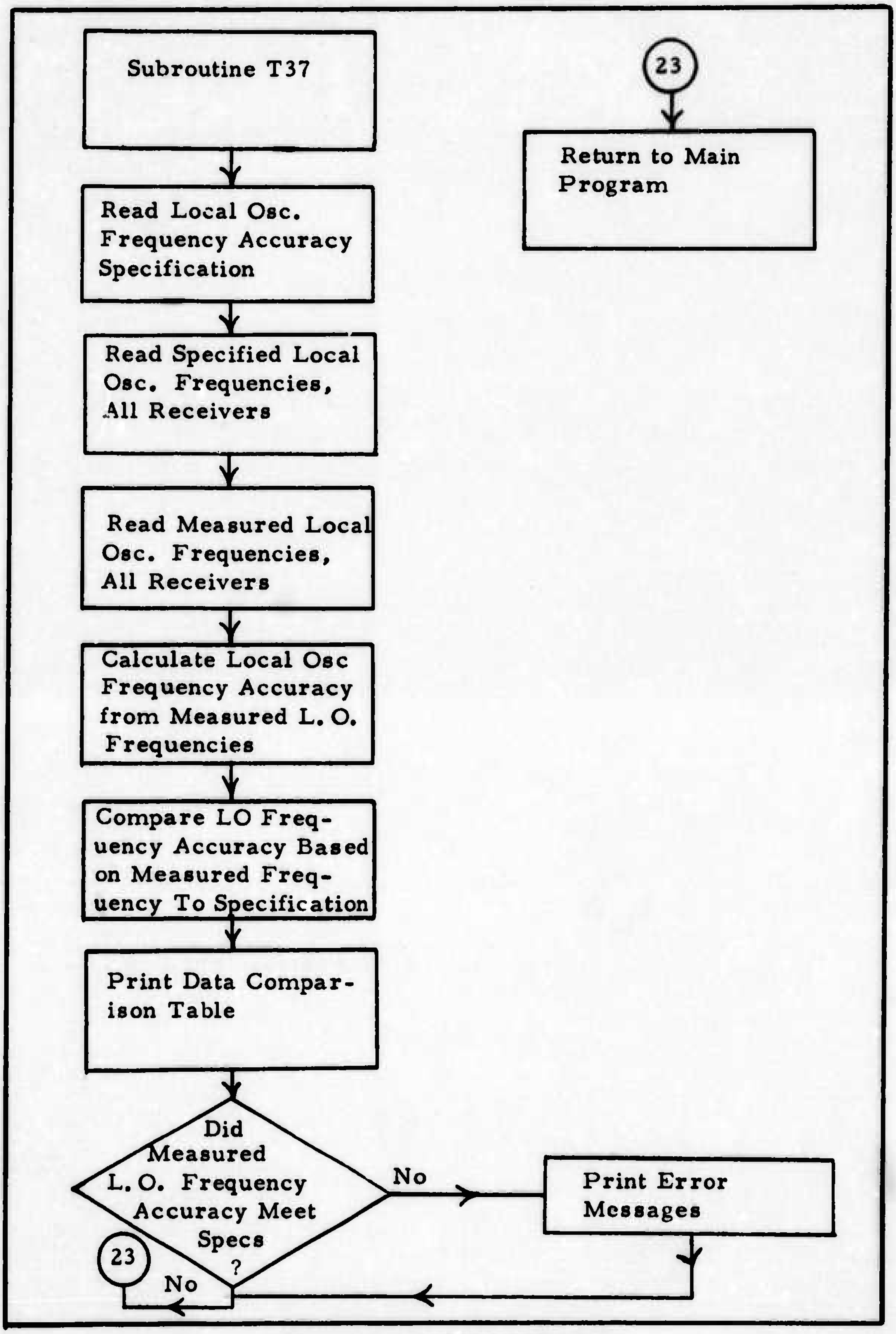

Fig. 32. SUBROUTINE T37

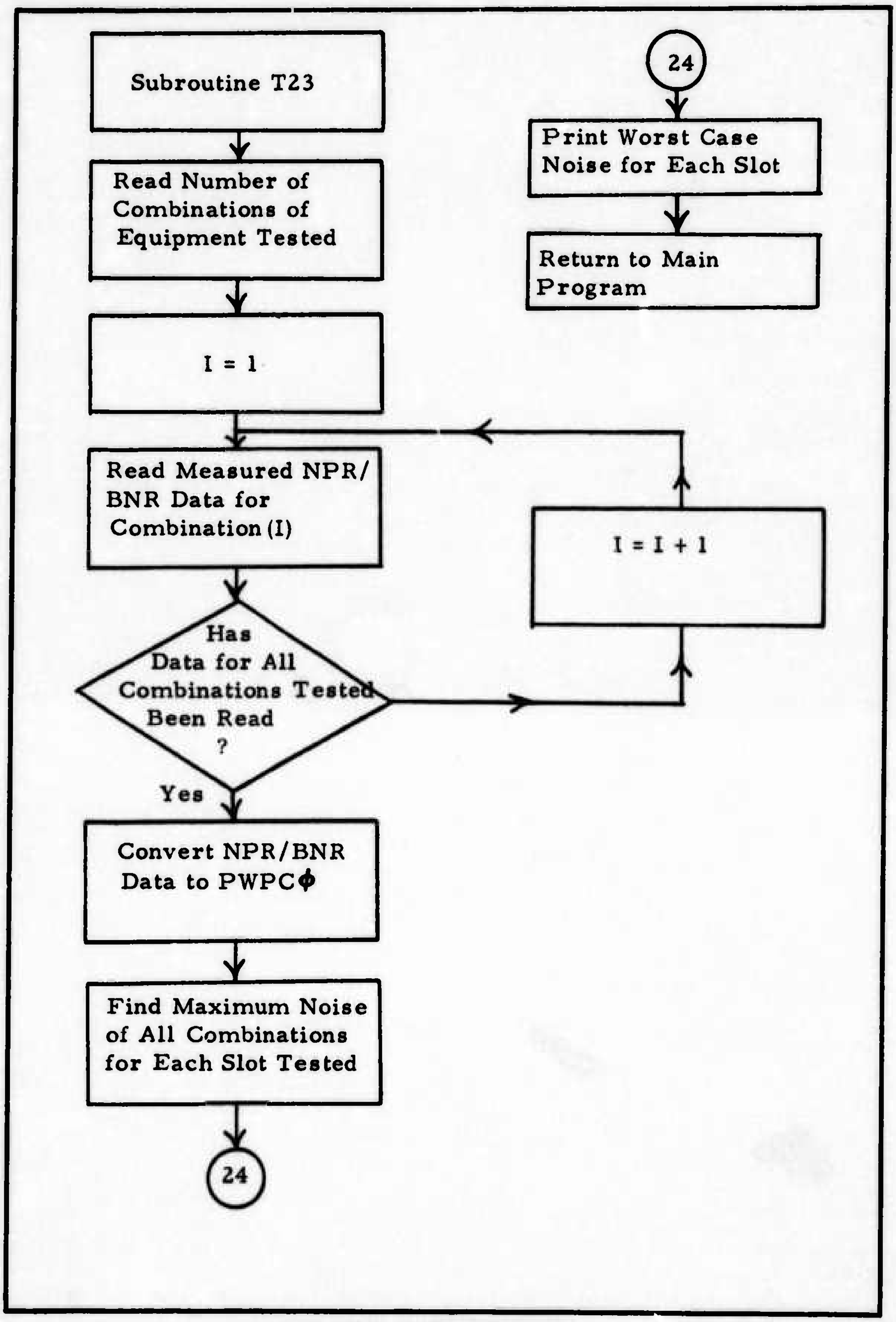

Fig. 33. SUBROUTINE T23

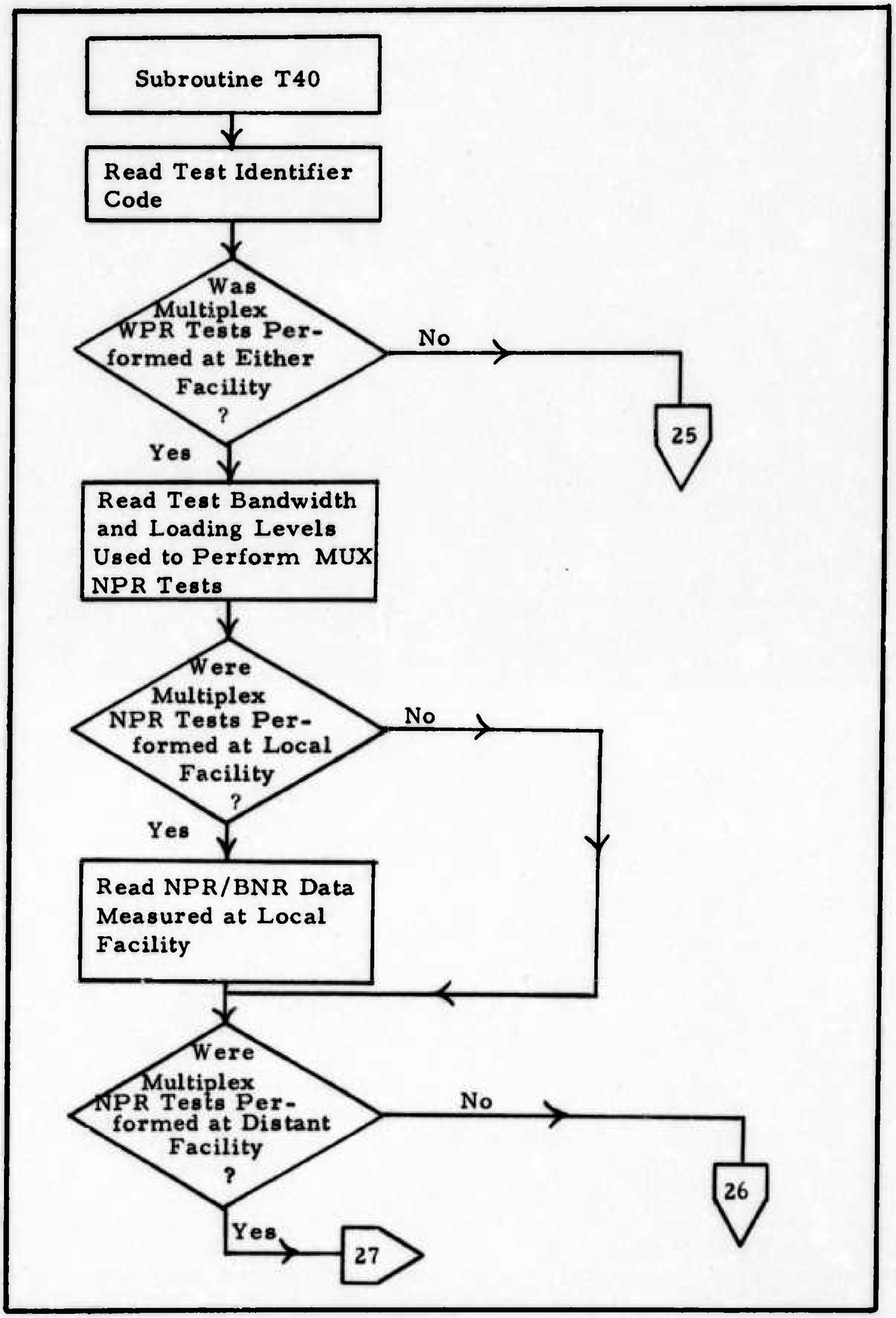

Fig. 34. SUBROUTINE T40

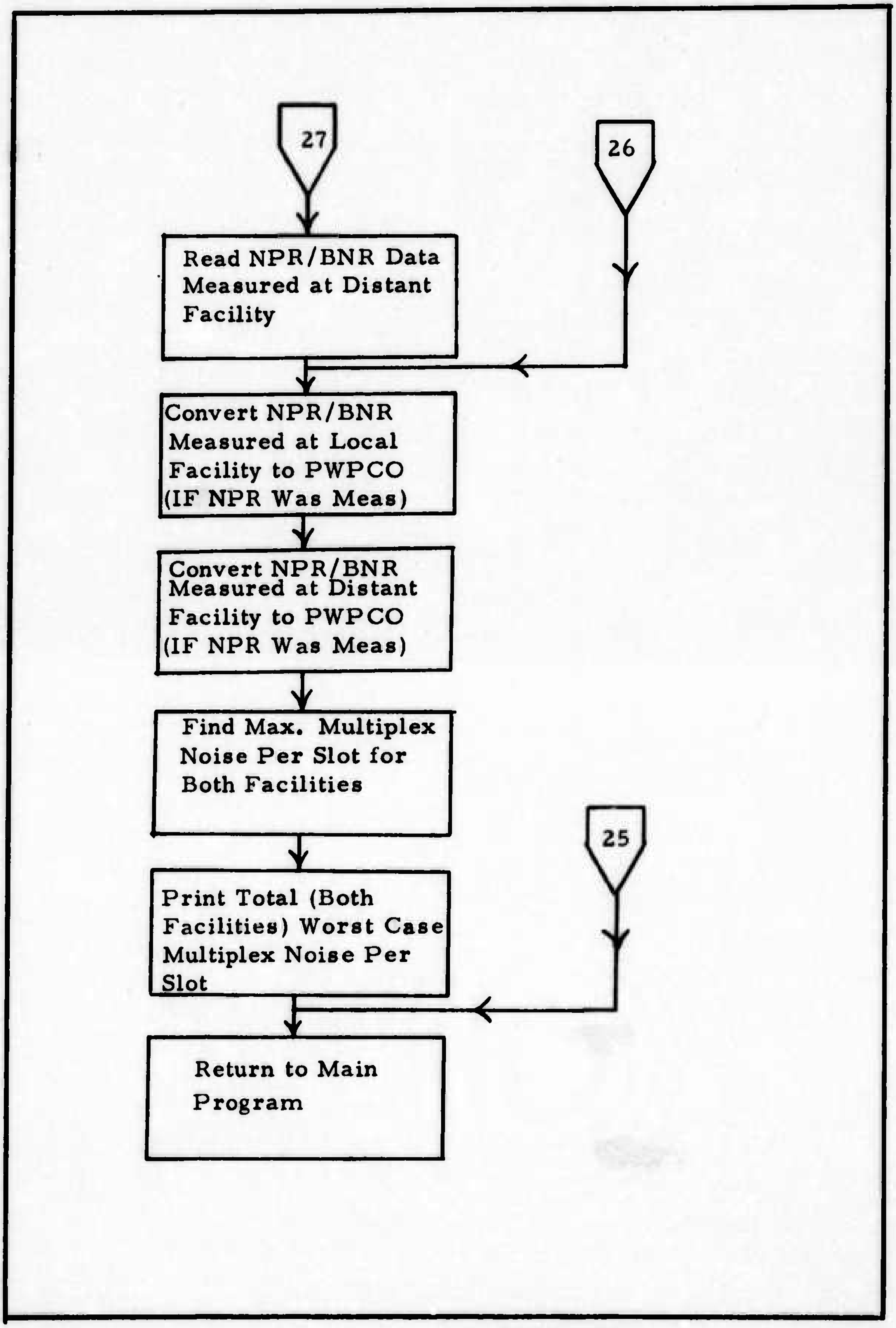

Fig. 35. SUBROUTINE T40 (cont)

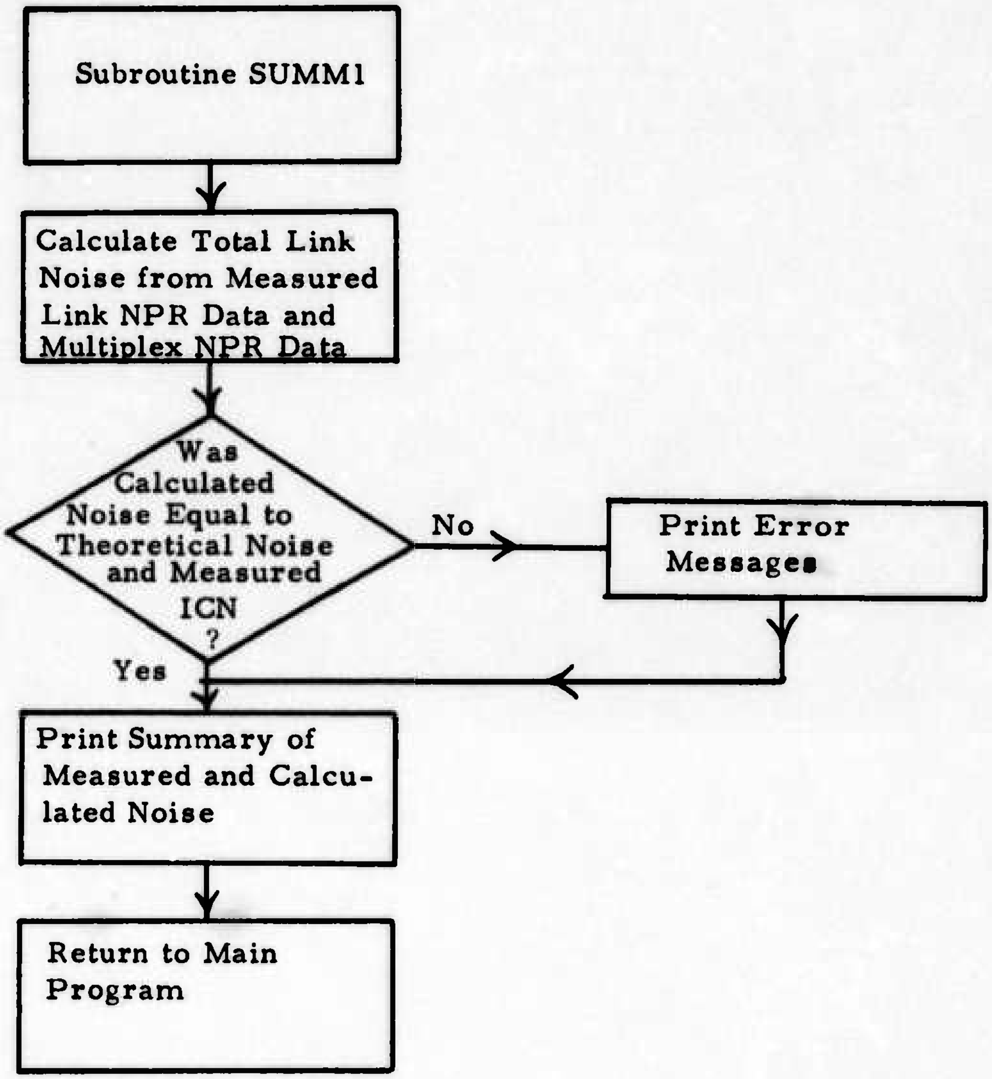

Fig. 36. SUBROUTINE SUMM1

Appendix C

Example of Program Output

SCOPE CREEK REPORT DATA ANALYSIS

STATION NUMBER ONE - FELDBERG, GER.

STATION NUMBER TWO - ADENAU, GER

DCA LINK NUMBER = M-0891

THEORETICAL PREDICTIONS BASED ON PATH PARAMETERS AND EQUIPMENT SPECS

THEORETICAL DATA FROM FELDBERG

EXPECTED UNFADED RSL FOR LINK = -40.04 DB

EXPECTED FADED RSL FOR LINK = -45.64 DB

THEORETICAL RECEIVER NOISE THRESHOLD = -88.02 DB

THEORETICAL MEDIAN CARRIER-TO-NOISE RATIO = 47.98 DB

THEORETICAL FM THRESHOLD = -78.02 DB

THEORETICAL FADE MARGIN = 32.38 DB

SINGLE RECEIVER OUTAGE PROBABILITY = .1111E-02

DIVERSITY OUTAGE PROBABILITY = .8670E-04

```
LOAD FACTOR CALCULATED FROM CCIR EQUATIONS =    9.77 DB

LOAD FACTOR CALCULATED FROM RCA EQUATIONS =   14.77 DB

CALCULATED PEAK DEVIATION = 1927.51 KHZ

CALCULATED MODULATION INDEX =   1.48

IF BANDWIDTH REQUIRED FOR NO DISTORTION =    9.055 MHZ

THEORETICAL RCVR THERMAL NOISE CALCULATED AT EXPECTED UNFADED RSL =    70.65 DB

THEORETICAL CHANNEL NOISE, RADIO EQUIPMENT ONLY =  17.251 DBRNC0

THEORETICAL TOTAL TRANSMISSION MEDIA NOISE PER CHANNEL = 20.549 DBRNC0

THEORETICAL TOTAL LINK NOISE, PER CHANNEL =  22.049 DBNNO

THEORETICAL TOTAL LINK NOISE, PER CHANNEL =  20.543 DBRNC0
```

THIS DATA WAS MEASURED AT FELDBERG

ANALYSIS AND SUMMARY OF RECEIVE SIGNAL LEVEL, IDLE CHANNEL NOISE, AND BASEBAND LOADING DATA MEASURED AT STATION NUMBER 1

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 MEDIAN RSL	-38.2	-40.0	1.8	
RCVR#2 MEDIAN RSL	-37.0	-40.0	3.0	TOLERANCE EXCEEDED, SEE NOTE 1
MEDIAN ICN	-73.2	-64.0	-9.2	
MEDIAN BBL	4.0	9.8** 9.2***	-5.8 -4.2	

** - THEORETICAL VALUE BASED ON # OF CHANNELS THE RADIO CAN CARRY
*** - THEORETICAL VALUE BASED ON ACTUAL # OF CHANNELS ON SYSTEM
**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

NOTE1 THE FOLLOWING ITEMS SHOULD BE EXAMINED TO DETERMINE REASONS FOR RSL DISPARITIES

1. DISTANT END TMTR#1 AND TMTR#2 MEASURED POWER
2. MEASURED VSWR: BOTH DISTANT AND LOCAL
3. DIVERSITY ARRANGEMENTS AND ANTENNA POLARIZATION
4. IF SPACE DIVERSITY IS USED, CHECK LINE LOSSES FOR EACH ANTENNA SYSTEM TO SEE IF THEY ARE THE SAME
5. IF MEASURED DATA DOES NOT EXPLAIN RSL DISCREPANCIES PATH PROFILE AND CALCULATIONS SHOULD BE RECHECKED

ANALYSIS AND SUMMARY OF VSWR AND POWER OUTPUT DATA MEASURED AT STATION NUMBER 1

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
TMTR01 VSWR	1.090	1.080	.010	STANDARD EXCEEDED, SEE NOTE 1
TMTR02 VSWR	1.080	1.080	0.000	
TMTR01 PWR OUT	37.0	37.0	0.0	
TMTR02 PWR OUT	37.5	37.0	.5	PWR HIGHER THAN RATED, SEE NOTE2

**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

NOTE1 VSWR WAS GREATER THAN STANDARD. THE FOLLOWING DATA SHOULD ALSO BE CHECKED

1. HIGH VSWR INDICATES POSSIBLE WAVEGUIDE DETERIORATIION AND HIGHER LINE LOSSES. RSL MEASURED ON DISTANT END RCVRS AT FREQ 8.3655GHZ MAY BE LOWER THAN CALCULATED.
2. RSL MEASURED ON RCVRS WHICH SHARE WAVEGUIDE SYSTEM WITH TMTR01 MAY BE LOWER THAN CALCULATED BECAUSE OF HIGH VSWR.
3. NPR DATA MEASURED WITH TMTR01 WAVEGUIDE IN THE TEST CONFIGURATION MAY INDICATE MORE DISTORTION THAN NORMAL.

NOTE2 TMTR PWR OUT WAS HIGHER THAN RATED PWR. THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE EFFECTS

***RSL MEASURED ON DISTANT RCVRS AT FREQ 8.3655GHZ SHOULD BE APPROXIMATELY .503 HIGHER THAN CALCULATED

ANALYSIS AND SUMMARY OF RECEIVER NOISE FIGURE DATA MEASURED AT STATION NUMBER 1

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 TOTAL NF	9.0	12.0	-3.0	SEE NOTE 6 BELOW
RCVR#2 TOTAL NF	9.5	12.0	-2.5	SEE NOTE 6 BELOW

**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

NOTE6
TOTAL RCVR NF WAS LESS THAN SPECIFICATION BY AMOUNT SHOWN IN DEV FROM THEORETICAL COLUMN.
THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE THE EFFECTS OF THIS DISCREPANCY.

1. IF IF BANDWIDTH IS EQUAL TO SPECIFICATION, FM THRESHOLD SHOULD OCCUR AT AN RSL LOWER THAN CALCULATED BY THE AMOUNT SHOWN IN THE DEV FROM THEORETICAL COLUMN.
2. IF RMS DEVIATION AND PREEMPHASIS EQUAL SPECIFICATIONS, THERMAL SNR WILL BE LOWER AT A PARTICULAR RSL BY THE AMOUNT SHOWN IN THE DEV FROM THEORETICAL COLUMN.

ANALYSIS AND SUMMARY OF IF AMPLIFIER AND DISCRIMINATOR BANDWIDTH DATA
MEASURED AT STATION NUMBER 1

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 IF BANDWIDTH	27.6	25.0** 9.1***	2.6 18.5	SEE NOTE#1 BELOW
RCVR#1 DISCR BW	42.0	9.1	32.9	
RCVR#2 IF BANDWIDTH	27.6	25.0** 9.1***	2.6 18.5	SEE NOTE#1 BELOW
RCVR#2 DISCR BW	41.0	9.1	31.9	

** - SPECIFIED IF BANDWIDTH
*** - BANDWIDTH REQUIRED TO PASS INFORMATION WITHOUT DISTORTION (CALCULATED VALUE)
**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

OTHER DISCREPANCIES NOTED IN DATA

NOTE1 IF BANDWIDTH WAS GREATER THAN SPECIFIED, THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE THE AFFECTS OF THE DISPARITY.

!!!IF NOISE FIGURE EQUALS SPECIFICATION, RCVR#1 FM THRESHOLD SHOULD OCCUR AT AN RSL .4DB HIGHER THAN CALCULATED.

!!!IF NOISE FIGURE EQUALS SPECIFICATION, RCVR#2 FM THRESHOLD SHOULD OCCUR AT AN RSL .4DB HIGHER THAN CALCULATED.

ANALYSIS AND SUMMARY OF PREAMP AND PRESELECTOR BANDWIDTH DATA
MEASURED AT STATION NUMBER 1

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 PREAMP BW	****			
RCVR#1 PRESELECTOR BW	****			
RCVR#1 TOTAL BW	39.5			
RCVR#2 PREAMP BW	****			
RCVR#2 PRESELECTOR BW	****			
RCVR#2 TOTAL BW	39.5			

**** - THIS PARAMETER WAS NOT MEASURED DURING THIS EVALUATION

OTHER DISCREPANCIES NOTED IN DATA

ANALYSIS AND SUMMARY OF RCVR#1 QUIETING CURVE DATA MEASURED AT STATION NUMBER 1

	MEASURED VALUE			CALCULATED VALUE			COMMENTS
	LO SLOT	MID SLOT	HI SLOT	LO SLOT	MID SLOT	HI SLOT	
RCVR#1 SNR AT -68.0 DBM	50.5	49.2	41.4	55.8* 58.0**	47.4* 50.4**	40.0* 43.0**	SEE NOTE#1 BELOW
RCVR#1 FM THRESHOLD	-52.5	-53.5	-76.5	-78.0* -80.6**	-78.0* -80.5**	-78.0* -80.5**	SEE NOTE#1 BELOW
RCVR#1 20DB QUIETING POINT	-80.1	-79.9	-80.0	-79.5* -82.1**	-79.5* -82.1**	-79.5* -82.1**	
RCVR#1 FM IMPROVEMENT FACTOR	54.6	39.1	26.2	45.1* 45.5**	27.5* 27.9**	20.1* 20.5**	SEE NOTE#1 BELOW
RCVR#1 SNR AT SIGNAL SATURATION	71.2	77.2	76.4				

AN ENTRY OF 0.0 INDICATES THAT DATA WAS NOT MEASURED OR WAS NOT CALCULATED BECAUSE OF LACK OF OTHER MEAS DATA.
* - INDICATES CALCULATIONS WERE BASED ON SPECS.
** - INDICATES CALCULATIONS WERE BASED ON OTHER MEAS DATA.

OTHER DISCREPANCIES NOTED IN DATA

NOTE1 RCVR#1 QUIETING CURVE DATA DOES NOT CORRELATE WITH OTHER MEASURED DATA.
THE FOLLOWING PROBLEMS WERE NOTED

- **** MEAS SNR ON RCVR#1 IN SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF MEASUREMENT, OR ERROR IN SLOT NOISE MEASUREMENTS.
- **** MEAS FM THRESHOLD ON RCVR#1 FOR SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.
- **** MEAS FM IMPROVEMENT FACTOR ON RCVR#1 FOR SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW

```
     MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.
**** MEAS SNR ON RCVR#1 IN SLOT#2 DOES NOT AGREE WITH CALCULATED
     VALUE BASED ON MEAS NF DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL
     GENERATOR, ERRORS IN NF MEASUREMENT, OR ERROR IN SLOT NOISE
     MEASUREMENTS.
**** MEAS FM THRESHOLD ON RCVR#1 FOR SLOT#2 DOES NOT AGREE WITH CAL-
     CULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A
     NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR
     ERRORS IN SLOT NOISE MEASUREMENTS.
**** MEAS FM IMPROVEMENT FACTOR ON RCVR#1 FOR SLOT#2 DOES NOT AGREE
     WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM
     MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW
     MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.
**** MEAS FM THRESHOLD ON RCVR#1 FOR SLOT#3 DOES NOT AGREE WITH CAL-
     CULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A
     NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR
     ERRORS IN SLOT NOISE MEASUREMENTS.
**** MEAS FM IMPROVEMENT FACTOR ON RCVR#1 FOR SLOT#3 DOES NOT AGREE
     WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM
     MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW
     MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.
```

ANALYSIS AND SUMMARY OF RCVR#2 QUIETING CURVE DATA MEASURED AT STATION NUMBER 1

	MEASURED VALUE			CALCULATED VALUE			COMMENTS
	LO SLOT	MID SLOT	HI SLOT	LO SLOT	MID SLOT	HI SLOT	
RCVR#2 SNR AT -55.0 DBM	48.5	44.3	41.6	65.0* 57.5**	47.4* 49.9**	40.0* 42.5**	SEE NOTE#1 BELOW
RCVR#2 FM THRESHOLD	-80.0	-78.0	-79.5	-78.0* -80.1**	-79.0* -80.1**	-78.0* -80.1**	SEE NOTE#1 BELOW
RCVR#2 20DB QUIETING POINT	-81.7	-81.5	-80.8	-79.5* -81.6**	-79.5* -81.5**	-79.5* -81.5**	
RCVR#2 FM IMPROVEMENT FACTOR	23.8	25.2	20.4	45.1* 45.5**	27.5* 27.9**	20.1* 20.5**	SEE NOTE#1 BELOW
RCVR#2 SNR AT SIGNAL SATURATION	71.9	77.1	76.9				

AN ENTRY OF 0.0 INDICATES THAT DATA WAS NOT MEASURED OR WAS NOT CALCULATED BECAUSE OF LACK OF OTHER MEAS DATA.
* - INDICATES CALCULATIONS WERE BASED ON SPECS.
** - INDICATES CALCULATIONS WERE BASED ON OTHER MEAS DATA.

** OTHER DISCREPANCIES NOTED IN DATA **

NOTE#1 RCVR#2 QUIETING CURVE DATA DOES NOT CORRELATE WITH OTHER MEASURED DATA.
THE FOLLOWING PROBLEMS WERE NOTED

**** MEAS SNR ON RCVR#2 IN SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF MEASUREMENT, OR ERROR IN SLOT NOISE MEASUREMENTS.

**** MEAS FM IMPROVEMENT FACTOR ON RCVR#2 FOR SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

**** MEAS SNR ON RCVR#2 IN SLOT#2 DOES NOT AGREE WITH CALCULATED

VALUE BASED ON MEAS NF DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF MEASUREMENT, OR ERROR IN SLOT NOISE MEASUREMENTS.

**** MEAS FM THRESHOLD ON RCVR#2 FOR SLOT#2 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

**** MEAS FM IMPROVEMENT FACTOR ON RCVR#2 FOR SLOT#2 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

ANALYSIS AND SUMMARY OF TRANSMITTER FREQUENCY DATA MEASURED AT STATION NUMBER 1

	MEASURED VALUE	THEORETICAL VALUE	FREQ ACCURACY	COMMENTS
TMTR#1 CARRIER FREQ	8365.5000	8365.5000	.0000000%	
TMTR#2 CARRIER FREQ	8365.5350	8365.5000	.0004184%	

***** - INDICATES MEAS FREQ EQUALED SPECIFIED FREQ

SUMMARY OF TOTAL LINK NOISE MEASURED AT STATION NUMBER1

**** TOTAL THEORETICAL WORST CASE CHANNEL NOISE BASED ON EQUIP SPECS = -68.0DBMO

**** MEASURED CHANNEL NOISE = -73.2DBMO

NOTE: NO MUX LOADED NOISE DATA WAS MEASURED AT EITHER STATION. IF MUX EQUIP WAS INSTALLED, THERE IS NOT ENOUGH DATA TO ACCURATELY PREDICT WORST CASE TOTAL NOISE. IF NO MUX EQUIP WAS INSTALLED, THE TOTAL WORST CASE NOISE SHOULD BE LESS THAN OR EQUAL TO NOISE MEASURED DURING LINK NPR TESTS. THUS, MEASURED CHANNEL NOISE SHOULD BE LESS THAN OR EQUAL TO-56.2DBMO.

ANALYSIS AND SUMMARY OF LOCAL OSCILLATOR FREQUENCY DATA
MEASURED AT STATION NUMBER 1

	MEASURED VALUE	THEORETICAL VALUE	FREQ ACCURACY	COMMENTS
RCVR#1 LO FREQUENCY	8134.5086	8134.5090	.0001055%	
RCVR#2 LO FREQUENCY	8134.5089	8134.5090	.0001090%	

***** - INDICATES MEAS FREQ EQUALED SPECIFIED FREQ

ANALYSIS AND SUMMARY OF LINK NPR AND SNR DATA MEASURED AT STATION NUMBER 1

**** MEASURED WORST CASE LOW SLOT TRANSMISSION MEDIA NOISE = 105.9 PWPCO
**** MEASURED WORST CASE MID SLOT TRANSMISSION MEDIA NOISE = 84.2 PWPCO
**** MEASURED WORST CASE HIGH SLOT TRANSMISSION MEDIA NOISE = 167.9 PWPCO

ANALYSIS AND SUMMARY OF MULTIPLEX LOADED NOISE MEASURED AT STATION NUMBER 1

NO MULTIPLEX LOADED NOISE DATA WAS MEASURED AT
AT THIS STATION

THEORETICAL DATA FROM ADENAU

EXPECTED UNFADED RSL FOR LINK = -49.21 DB

EXPECTED FADED RSL FOR LINK = -45.81 DB

THEORETICAL RECEIVER NOISE THRESHOLD = -88.02 DB

THEORETICAL MEDIAN CARRIER-TO-NOISE RATIO = 47.91 DB

THEORETICAL FM THRESHOLD = -78.02 DB

THEORETICAL FADE MARGIN = 32.21 DB

SINGLE RECEIVER OUTAGE PROBABILITY = .1159E-02

DIVERSITY OUTAGE PROBABILITY = .9462E-04

LOAD FACTOR CALCULATED FROM CCIR EQUATIONS = 9.77 DB

LOAD FACTOR CALCULATED FROM DCA EQUATIONS = 14.77 DB

CALCULATED PEAK DEVIATION = 1927.51 KHZ

CALCULATED MODULATION INDEX = 1.48

IF BANDWIDTH REQUIRED FOR NO DISTORTION = 9.055 MHZ

THEORETICAL RCVR THERMAL NOISE CALCULATED AT EXPECTED UNFADED RSL = 70.52 DB

THEORETICAL CHANNEL NOISE, RADIO EQUIPMENT ONLY = 17.251 DBRNCO

THEORETICAL TOTAL TRANSMISSION MEDIA NOISE PER CHANNEL = 20.639 DBRNCO

THEORETICAL TOTAL LINK NOISE, PER CHANNEL = 22.139 DBNNO

THEORETICAL TOTAL LINK NOISE, PER CHANNEL = 20.539 DBRNCO

THIS DATA WAS MEASURED AT ADENAU

ANALYSIS AND SUMMARY OF RECEIVE SIGNAL LEVEL, IDLE CHANNEL NOISE, AND BASEBAND LOADING DATA MEASURED AT STATION NUMBER 2

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 MEDIAN RSL	-38.6	-40.2	1.6	
RCVR#2 MEDIAN RSL	-35.5	-40.2	4.6	TOLERANCE EXCEEDED, SEE NOTE 1
MEDIAN ICN	-74.9	-64.0	-10.9	
MEDIAN BBL	4.5	9.8** 8.2***	-5.3 -3.7	

** - THEORETICAL VALUE BASED ON # OF CHANNELS THE RADIO CAN CARRY
*** - THEORETICAL VALUE BASED ON ACTUAL # OF CHANNELS ON SYSTEM
**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

NOTE1 THE FOLLOWING ITEMS SHOULD BE EXAMINED TO DETERMINE REASONS FOR RSL DISPARITIES

1. DISTANT END TMTR#1 AND TMTR#2 MEASURED POWER
2. MEASURED VSWR: BOTH DISTANT AND LOCAL
3. DIVERSITY ARRANGEMENTS AND ANTENNA POLARIZATION
4. IF SPACE DIVERSITY IS USED, CHECK LINE LOSSES FOR EACH ANTENNA SYSTEM TO SEE IF THEY ARE THE SAME
5. IF MEASURED DATA DOES NOT EXPLAIN RSL DISCREPANCIES PATH PROFILE AND CALCULATIONS SHOULD BE RECHECKED

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ANALYSIS AND SUMMARY OF VSWR AND POWER OUTPUT DATA MEASURED AT STATION NUMBER 2

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
TMTR#1 VSWR	1.100	1.080	.020	STANDARD EXCEEDED, SEE NOTE 1
TMTR#2 VSWR	1.080	1.080	0.000	
TMTR#1 PWR OUT	36.0	37.0	-1.0	PWR LOWER THAN RATED, SEE NOTE 3
TMTR#2 PWR OUT	37.4	37.0	.4	PWR HIGHER THAN RATED, SEE NOTE2

**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

NOTE1 VSWR WAS GREATER THAN STANDARD. THE FOLLOWING DATA SHOULD ALSO BE CHECKED

1. HIGH VSWR INDICATES POSSIBLE WAVEGUIDE DETERIORATION AND HIGHER LINE LOSSES. RSL MEASURED ON DISTANT END RCVRS AT FREQ 8.2405GHZ MAY BE LOWER THAN CALCULATED.
2. RSL MEASURED ON RCVRS WHICH SHARE WAVEGUIDE SYSTEM WITH TMTR#1 MAY BE LOWER THAN CALCULATED BECAUSE OF HIGH VSWR.
3. NPR DATA MEASURED WITH TMTR#1 WAVEGUIDE IN THE TEST CONFIGURATION MAY INDICATE MORE DISTORTION THAN NORMAL.

NOTE2 TMTR PWR OUT WAS HIGHER THAN RATED PWR. THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE EFFECTS

***RSL MEASURED ON DISTANT RCVRS AT FREQ 8.2655GHZ SHOULD BE APPROXIMATELY .403 HIGHER THAN CALCULATED

NOTE3 TMTR PWR OUT WAS LOWER THAN RATED PWR. THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE EFFECTS

***RSL MEASURED ON DISTANT RCVRS AT FREQ 8.2405GHZ SHOULD BE APPROXIMATELY 1.003 LOWER THAN CALCULATED

ANALYSIS AND SUMMARY OF RECEIVER NOISE FIGURE DATA MEASURED AT STATION NUMBER 2

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 TOTAL NF	9.2	12.0	-2.8	SEE NOTE 6 BELOW
RCVR#2 TOTAL NF	10.6	12.0	-1.4	SEE NOTE 6 BELOW

**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

NOTE6 TOTAL RCVR NF WAS LESS THAN SPECIFICATION BY AMOUNT SHOWN IN DEV FROM THEORETICAL COLUMN. THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE THE EFFECTS OF THIS DISCREPANCY.

1. IF IF BANDWIDTH IS EQUAL TO SPECIFICATION, FM THRESHOLD SHOULD OCCUR AT AN RSL LOWER THAN CALCULATED BY THE AMOUNT SHOWN IN THE DEV FROM THEORETICAL COLUMN.
2. IF RMS DEVIATION AND PREEMPHASIS EQUAL SPECIFICATIONS, THERMAL SNR WILL BE LOWER AT A PARTICULAR RSL BY THE AMOUNT SHOWN IN THE DEV FROM THEORETICAL COLUMN.

ANALYSIS AND SUMMARY OF IF AMPLIFIER AND DISCRIMINATOR BANDWIDTH DATA
MEASURED AT STATION NUMBER 2

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 IF BANDWIDTH	26.5	25.0**	1.5	SEE NOTE#1 BELOW
		9.1***	17.4	
RCVR#1 DISCR BW	37.0	9.1	27.9	
RCVR#2 IF BANDWIDTH	24.6	25.0**	-.4	SEE NOTE#2 BELOW
		9.1***	15.5	
RCVR#2 DISCR BW	36.0	9.1	26.9	

** - SPECIFIED IF BANDWIDTH
*** - BANDWIDTH REQUIRED TO PASS INFORMATION WITHOUT DISTORTION (CALCULATED VALUE)
**** - THIS PARAMETER WAS NOT MEASURED DURING THE EVALUATION

OTHER DISCREPANCIES NOTED IN DATA

NOTE1 IF BANDWIDTH WAS GREATER THAN SPECIFIED, THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE THE AFFECTS OF THE DISPARITY.
***IF NOISE FIGURE EQUALS SPECIFICATION, RCVR#1 FM THRESHOLD SHOULD OCCUR AT AN RSL .30B HIGHER THAN CALCULATED.

NOTE2 IF BANDWIDTH WAS LESS THAN SPECIFIED, THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE THE AFFECTS OF THE DISPARITY.
***IF NOISE FIGURE EQUALS SPECIFICATION, RCVR#2 FM THRESHOLD SHOULD OCCUR AT AN RSL -.10B LOWER THAN CALCULATED.

ANALYSIS AND SUMMARY OF PREAMP AND PRESELECTOR BANDWIDTH DATA
MEASURED AT STATION NUMBER 2

	MEASURED VALUE	THEORETICAL VALUE	DEV FROM THEORETICAL	COMMENTS
RCVR#1 PREAMP BW	****			
RCVR#1 PRESELECTOR BW	****			
RCVR#1 TOTAL BW	42.0			
RCVR#2 PREAMP BW	****			
RCVR#2 PRESELECTOR BW	****			
RCVR#2 TOTAL BW	41.0			

**** - THIS PARAMETER WAS NOT MEASURED DURING THIS EVALUATION

OTHER DISCREPANCIES NOTED IN DATA

ANALYSIS AND SUMMARY OF RCVR#1 QUIETING CURVE DATA MEASURED AT STATION NUMBER 2

	MEASURED VALUE			CALCULATED VALUE			COMMENTS
	LO SLOT	MID SLOT	HI SLOT	LO SLOT	MID SLOT	HI SLOT	
RCVR#1 SNR AT -68.0 DBM	51.9	45.1	43.5	65.0* 57.8**	47.4* 50.2**	40.0* 42.8**	SEE NOTE#1 BELOW
RCVR#1 FM THRESHOLD	0.0	-59.0	-76.0	-78.0* -80.6**	-78.0* -80.5**	-78.0* -80.6**	SEE NOTE#1 BELOW
RCVR#1 20DB QUIETING POINT	-81.6	-81.2	-81.9	-79.5* -82.1**	-79.5* -82.1**	-79.5* -82.1**	
RCVR#1 FM IMPROVEMENT FACTOR	0.0	41.5	27.9	45.1* 45.4**	27.5* 27.7**	20.1* 20.3**	SEE NOTE#1 BELOW
RCVR#1 SNR AT SIGNAL SATURATION	77.3	77.3	77.8				

AN ENTRY OF 0.0 INDICATES THAT DATA WAS NOT MEASURED OR WAS NOT CALCULATED BECAUSE OF LACK OF OTHER MEAS DATA.
* - INDICATES CALCULATIONS WERE BASED ON SPECS.
** - INDICATES CALCULATIONS WERE BASED ON OTHER MEAS DATA.

OTHER DISCREPANCIES NOTED IN DATA

*** RCVR#1 SLOT#1 NOISE DATA EXHIBITED NO LINEAR REGION ABOVE THRESHOLD. PROBLEM COULD BE DUE TO NOISY SIGNAL GENERATOR OR MEASUREMENT ERRORS. DATA SHOULD BE CONSIDERED INVALID.

NOTE1 RCVR#1 QUIETING CURVE DATA DOES NOT CORRELATE WITH OTHER MEASURED DATA. THE FOLLOWING PROBLEMS WERE NOTED

**** MEAS SNR ON RCVR#1 IN SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF MEASUREMENT, OR ERROR IN SLOT NOISE MEASUREMENTS.

**** MEAS SNR ON RCVR#1 IN SLOT#2 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF MEASUREMENT, OR ERROR IN SLOT NOISE MEASUREMENTS.

```
**** MEAS FM THRESHOLD ON RCVR#1 FOR SLOT#2 DOES NOT AGREE WITH CAL-
     CULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A
     NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR
     ERRORS IN SLOT NOISE MEASUREMENTS.
**** MEAS FM IMPROVEMENT FACTOR ON RCVR#1 FOR SLOT#2 DOES NOT AGREE
     WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM
     MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW
     MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.
**** MEAS FM THRESHOLD ON RCVR#1 FOR SLOT#3 DOES NOT AGREE WITH CAL-
     CULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A
     NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR
     ERRORS IN SLOT NOISE MEASUREMENTS.
**** MEAS FM IMPROVEMENT FACTOR ON RCVR#1 FOR SLOT#3 DOES NOT AGREE
     WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM
     MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW
     MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.
```

ANALYSIS AND SUMMARY OF RCVR#2 QUIETING CURVE DATA MEASURED AT STATION NUMBER 2

	MEASURED VALUE			CALCULATED VALUE			COMMENTS
	LO SLOT	MID SLOT	HI SLOT	LO SLOT	MID SLOT	HI SLOT	
RCVR#2 SNR AT -58.0 DBM	52.4	49.7	42.4	55.0* 56.4**	47.4* 48.9**	40.0* 41.4**	SEE NOTE#1 BELOW
RCVR#2 FM THRESHOLD	-54.0	-69.0	-76.0	-78.0* -79.5**	-78.0* -79.3**	-78.0* -79.5**	SEE NOTE#1 BELOW
RCVR#2 20DB QUIETING POINT	-92.0	-91.8	-81.5	-79.5* -81.0**	-79.3* -81.0**	-79.5* -81.0**	
RCVR#2 FM IMPROVEMENT FACTOR	54.0	42.5	29.0	45.1* 45.0**	27.5* 27.4**	28.1* 28.0**	SEE NOTE#1 BELOW
RCVR#2 SNR AT SIGNAL SATURATION	57.3	75.9	76.8				

AN ENTRY OF 0.0 INDICATES THAT DATA WAS NOT MEASURED OR WAS NOT CALCULATED BECAUSE OF LACK OF OTHER MEAS DATA.
* - INDICATES CALCULATIONS WERE BASED ON SPECS.
** - INDICATES CALCULATIONS WERE BASED ON OTHER MEAS DATA.

OTHER DISCREPANCIES NOTED IN DATA

NOTE1 RCVR#2 QUIETING CURVE DATA DOES NOT CORRELATE WITH OTHER MEASURED DATA.
THE FOLLOWING PROBLEMS WERE NOTED

**** MEAS SNR ON RCVR#2 IN SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF MEASUREMENT, OR ERROR IN SLOT NOISE MEASUREMENTS.

**** MEAS FM THRESHOLD ON RCVR#2 FOR SLOT#1 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND BW DATA, PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

**** MEAS FM IMPROVEMENT FACTOR ON RCVR#2 FOR SLOT#1 DOES NOT AGREE

WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

**** MEAS FM THRESHOLD ON RCVR#2 FOR SLOT#2 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

**** MEAS FM IMPROVEMENT FACTOR ON RCVR#2 FOR SLOT#2 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

**** MEAS FM THRESHOLD ON RCVR#2 FOR SLOT#3 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND BW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

**** MEAS FM IMPROVEMENT FACTOR ON RCVR#2 FOR SLOT#3 DOES NOT AGREE WITH CALCULATED VALUE BASED ON MEAS NF AND IFBW DATA. PROBLEM MAY BE DUE TO A NOISY SIGNAL GENERATOR, ERRORS IN NF OR IFBW MEASUREMENTS, OR ERRORS IN SLOT NOISE MEASUREMENTS.

ANALYSIS AND SUMMARY OF TRANSMITTER FREQUENCY DATA MEASURED AT STATION NUMBER 2

	MEASURED VALUE	THEORETICAL VALUE	FREQ ACCURACY	COMMENTS
TMTR#1 CARRIER FREQ	8204.5160	8240.4500	.4360584%	STAND WAS NOT MET, SEE NOTE#1
TMTR#2 CARRIER FREQ	8204.5003	8204.5000	.0000037%	

***** - INDICATES MEAS FREQ EQUALED SPECIFIED FREQ

NOTE1 FREQ ACCURACY DID NOT MEET SPECS. THE FOLLOWING DATA SHOULD BE CHECKED TO DETERMINE EFFECTS

1. IDLE CHANNEL NOISE MEASURED AT DISTANT STATION TO SEE IF FREQ DISCREPANCY CAUSED AN INCREASE IN DISTORTION.
2. LINK NPRS MEASURED AT DISTANT STATION TO SEE IF DISTORTION WAS HIGHER THAN EXPECTED.

ANALYSIS AND SUMMARY OF LOCAL OSCILLATOR FREQUENCY DATA
MEASURED AT STATION NUMBER 2

	MEASURED VALUE	THEORETICAL VALUE	FREQ ACCURACY	COMMENTS
RCVR#1 LO FREQUENCY	8295.4967	8295.5000	.0000398%	
RCVR#2 LO FREQUENCY	8295.5166	8295.5000	.0002001%	

***** - INDICATES MEAS FREQ EQUALED SPECIFIED FREQ

ANALYSIS AND SUMMARY OF LINK NPR AND BNR DATA MEASURED AT STATION NUMBER 2

**** MEASURED WORST CASE LOW SLOT TRANSMISSION MEDIA NOISE = 211.4 PWPO0
**** MEASURED WORST CASE MID SLOT TRANSMISSION MEDIA NOISE = 266.1 PWPO0
**** MEASURED WORST CASE HIGH SLOT TRANSMISSION MEDIA NOISE = 211.4 PWPO0

ANALYSIS AND SUMMARY OF MULTIPLEX LOADED NOISE MEASURED AT STATION NUMBER 2

NO MULTIPLEX LOADED NOISE DATA WAS MEASURED AT
AT THIS STATION

SUMMARY OF TOTAL LINK NOISE MEASURED AT STATION NUMBER 2

**** TOTAL THEORETICAL WORST CASE CHANNEL NOISE BASED ON EQUIP SPECS = -67.9DBMO

**** MEASURED CHANNEL NOISE = -74.9DBMO

NOTE: NO MUX LOADED NOISE DATA WAS MEASURED AT EITHER STATION. IF MUX EQUIP WAS INSTALLED, THERE IS NOT ENOUGH DATA TO ACCURATELY PREDICT WORST CASE TOTAL NOISE. IF NO MUX EQUIP WAS INSTALLED, THE TOTAL WORST CASE NOISE SHOULD BE LESS THAN OR EQUAL TO NOISE MEASURED DURING LINK NPR TESTS. THUS, MEASURED CHANNEL NOISE SHOULD BE LESS THAN OR EQUAL TO-54.2DBMO.

Vita

Earl F. Reynolds was born [redacted] In 1964, he was graduated from [redacted] He received an Associate Degree in Applied Sciences from Roanoke Technical Institute in 1966.

Captain Reynolds entered the Air Force in July 1966 and served as a missile instrumentation technician at Hill AFB, Utah after completing basic training and technical school training. In December 1968, he was selected for the Airmen's Education and Commissioning program and assigned to the University of Missouri, Columbia, Missouri, to complete his undergraduate work. He received a Bachelor of Science in Electrical Engineering from the University of Missouri in January 1970.

He attended Officer Training School and was commissioned in May, 1970. He then attended the Communications Officer Training School at Keesler AFB, Mississippi, until November 1970. He was then assigned to Hickam AFB, Hawaii where he served as a Scope Creek Evaluation Team Chief until entering the School of Engineering. Air Force Institute of Technology, in May 1975.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER GE/EE/76D-39	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ANALYSIS OF WIDEBAND SCOPE CREEK REPORT DATA USING COMPUTER TECHNIQUES		5. TYPE OF REPORT & PERIOD COVERED MS Thesis
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Earl F. Reynolds Captain		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Institute of Technology (AFIT/EN) Wright-Patterson AFB, Ohio 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Headquarters Air Force Communications Service DOYMS Richards-Gebaur AFB, Missouri		12. REPORT DATE December 1976
		13. NUMBER OF PAGES 152
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Approved for public release; IAW AFR 190-17

JERRAL F. GUESS, Captain, USAF
Director of Information

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Scope Creek
Communications Theory
Computer Program

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A computer program which performs analysis on data measured during Scope Creek evaluations has been developed. The program is capable of analyzing data measured on both line-of-sight and troposcatter communications systems. Both individual equipment and system measured data can be analyzed by the program.

The models used by Scope Creek engineers, and in the program, to predict

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theoretical performance of communications systems are presented. Recommendations are given to improve the accuracy of the theoretical models and usefulness of the Scope Creek data.